BRITISH · PTERIDOLOGICAL · SOCIETY

THE FERN GAZETTE

EDITORS:
J.M. CAMUS & J.A. CRABBE

VOLUME 16 PART 4 2001

THE FERN GAZETTE is a journal of the British Pteridological Society and contains peer-reviewed papers on all aspects of pteridology.

Manuscripts may be submitted, and books etc sent for review, to Miss J. M. Camus, Department of Botany, The Natural History Museum, Cromwell Road, London SW7 5BD, UK.

Instructions for authors are on p. 169 of this volume and available at http://www.eBPS.org.uk

Copyright © 2001 British Pteridological Society. All rights reserved. No part of this publication may be reproduced in any material form (including photocopying or storing it in any medium by electronic means) without the permission of the British Pteridological Society.

THE FERN GAZETTE Volume 16 Parts 3 was published on 5 December 2000

Published by THE BRITISH PTERIDOLOGICAL SOCIETY, c/o Department of Botany, The Natural History Museum, London SW7 5BD, UK

Printed by The Electronic Document Co., 132b King Street, London W6 0QU, UK

Cover design by Hazel Sims

ISOETES SINENSIS VAR. *SINENSIS* IN KOREA (ISOETACEAE: PTERIDOPHYTA)

M. TAKAMIYA

Department of Environmental Science, Faculty of Science, Kumamoto University, Kurokami 2-39-1, Kumamoto 860-8555, Japan
(Email: lycopod@aster.sci.kumamoto-u.ac.jp)

Key words: chromosome, *Isoetes*, Korea, spore

ABSTRACT

Quillworts recently collected from a population on Cheju Island, South Korea, are tetraploid ($2n = 44 = 22_{II}$) and have cristate megaspores and echinate microspores. Based on these characters, the specimens are identified as *Isoetes sinensis* var. *sinensis*, a globally rare taxon previously unreported in Korea. The apparently close taxonomic relationship between Korean *I. sinensis* var. *sinensis* and the basic diploid *I. taiwanensis* suggests that further phylogenetic investigation is warranted.

INTRODUCTION

Taxonomic information on quillworts in eastern Asia is limited in comparison to the body of data resulting from active investigations in North America (Britton & Brunton, 1989, 1991, 1992, 1993, 1995, 1996; Brunton & Taylor, 1990; Britton, 1991; Britton & Goltz, 1991; Brunton & Britton, 1996a, b, 1997, 1998, 1999; Taylor *et al.*, 1985, 1993; Taylor & Luebke, 1988; Brunton *et al.*, 1994, 1996; Musselman & Knepper, 1994, Musselman *et al.*, 1996, 1997; Britton *et al.*, 1999) and India (Panigrahi, 1981; Srivastava *et al.*, 1993; Srivastava, 1998). Until recently, only two or three species had been reported in China (Wu & Ching, 1991), one in Taiwan (DeVol, 1972), three in Korea (Chung & Choi, 1986; Lee, 1989, 1996), and three in Japan (Iwatsuki, 1995). Takamiya *et al.* (1997), however, indicate that four species, two varieties and one hybrid exist in Japan. This suggests that more intensive searches may reveal additional quillwort taxa of eastern Asia.

In this paper morphological, cytological and spore ornamentation characteristics of an additional Korean quillwort are examined and its taxonomic relationship to other eastern Asian *Isoetes* species is considered.

MATERIALS AND METHODS

Specimens of *Isoetes* were collected from a pond at Shincheon, Namcheju-Gun, Cheju Island, South Korea (Fig. 1) on September 18, 1996 by Mr Mitsuru Miyabe. Two juvenile, sterile plants from this collection were cultivated in pots in a shallow pond at the Botanical Garden, Faculty of Science, Kumamoto University. After one year in cultivation both plants matured and produced mega- and microsporangia.

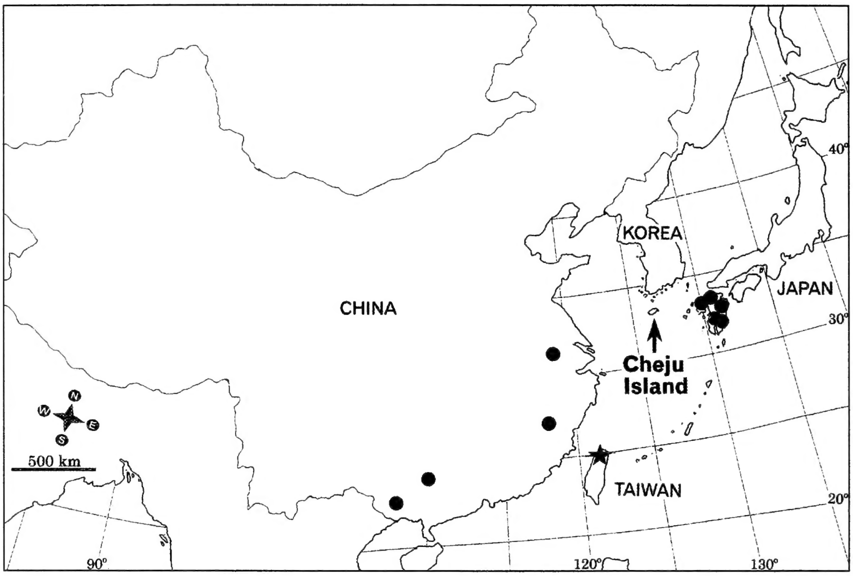


Figure 1. Distribution of *Isoetes sinensis* var. *sinensis* and the collection site in Korea. ● = populations of *I. sinensis* var. *sinensis*. ★ = population of *I. taiwanense*. ➔ = Cheju Island, South Korea.

The mitotic chromosome number and meiotic chromosome configurations were determined following the methods described in Takamiya *et al.* (1994, 1996). Spore measurements and Scanning Electron Microscope (SEM) observation of surface morphology follow the protocol given in Watanabe *et al.* (1996). Terminology and classification of the spores follow Kott and Britton (1983), Hickey (1986), and Tryon and Lugardon (1990). Nomenclature follows Takamiya *et al.* (1997). Voucher specimens (*Miyabe & Takamiya 1, 2)* were deposited in the herbarium of Kumamoto University (KUMA). A distribution map based on Marsden (1979) and Takamiya *et al.* (1997) was prepared. Specimens deposited in the herbarium of Chinese Academy of Sciences, Beijing (PE) were also investigated and their data were added to this map.

RESULTS

Morphology

The Korean plant is a summer-green and aquatic herb with a 3-lobed corm. Leaves are erect in stature and are light green with white bases that are expanded into semi-membranous wings. Stomata and four peripheral fibre strands are present. Internal hairs appear to be absent within the lacunae. Lacunae walls are mostly 2-cell thick; steles are well developed with three intrastelar canals. Trans-lacunar diaphragms are visible through the leaves. Ligules are elongate-triangular with cordate base. No

evidence of a labium or velum was noted. Sporangia are orbicular, oblong or elliptical. Sporangial walls are pale and translucent, sometimes spotted with clusters of thickened pigmented cell walls.

Cytology

The mitotic chromosome number of the two Korean plants was determined to be 2n = 44 (Fig. 2A), indicating a tetraploid. Consistently, 22 bivalents were observed at diakinesis and/or metaphase I during microsporogenesis (Figs 2B-C). Throughout the process of microsporogenesis, no irregularities were detected and microspores with normal appearance were ultimately produced. The mitotic chromosome number was reduced to half in microsporogenesis, indicating that plants should reproduce sexually.

Spore ornamentation

Proximal, lateral and distal faces of the megaspores are covered with disconnected cristate muri of an irregular height (Figs 3A-C). This megaspore pattern has accordingly been classified as cristate (Hickey, 1986). The muri vary from 5-10μm in width and 10 - 30μm in height, with an apex that is usually serrate. The muri are short and isolated on the proximal face. At high magnification, the surface is seen to be covered with fibrils 0.8μm in diameter and 5.0μm in length, which are densely intertwined. No abnormally shaped spores were observed.

The microspore wall is covered with conical spines over proximal, lateral and distal surfaces (Figs 3D-F). This ornamentation pattern has been categorized as echinate (Tryon & Lugardon, 1990). These conical spines are 0.5-1.0μm in basal diameter, 1.0-2.5μm in height and about 15 per 100μm^2 in density. Many granules are also scattered over the surface.

The mean diameter of the megaspores is 405.3 ± 39.02μm [N = 50] and the mean length of the microspores is from 26.8 ±1.02μm [N = 100].

DISCUSSION

From morphological, cytological and spore ornamentation analyses, the quillwort collected from Cheju Island, Korea is concluded to represent *Isoetes sinensis* T.C.Palmer var. *sinensis*, as per Takamiya *et al.* (1997).

Three species of *Isoetes*, *I. asiatica* (Makino) Makino, *I. japonica* A.Braun and the endemic *I. coreana* Y.H.Chung & H.K.Choi, were previously reported from the Korean flora (Park, 1942; Chung & Choi, 1986; Lee, 1989, 1996). Takamiya *et al.* (1997) indicate that the latter species occurs in several places of western Japan, and is better treated within the *I. sinensis* complex as *I. sinensis* var. *coreana* (Y.H.Chung & H.K.Choi) M.Takamiya, M.Watanabe & K.Ono. The present study, therefore, establishes *I. sinensis* var. *sinensis* as the fourth *Isoetes* taxon in Korea.
Isoetes sinensis var. *sinensis* was described from Nanking, China (Palmer, 1927) and is a sexual tetraploid (Takamiya *et al.*, 1997). It occurs in China, Korea, and eastward to Kyushu, Japan (Fig. 1). With fewer than ten populations known in Japan it is in danger of extinction. Walter and Gillett (1998) listed it as a Vulnerable species in China and Japan. The population of *I. sinensis* var. *sinensis* on Cheju Island is the only known record for this taxon in Korea. This taxon, therefore, is likely of global conservation concern.

Figure 2. Mitotic and meiotic chromosomes of Korean *Isoetes sinensis* var. *sinensis* (*Miyabe & Takamiya 2*). **A**. Mitosis (2n = 44). **B**. Diakinesis, and **C**. Metaphase I of microsporogenesis (n = 22). Bar = 5μm for all figures.

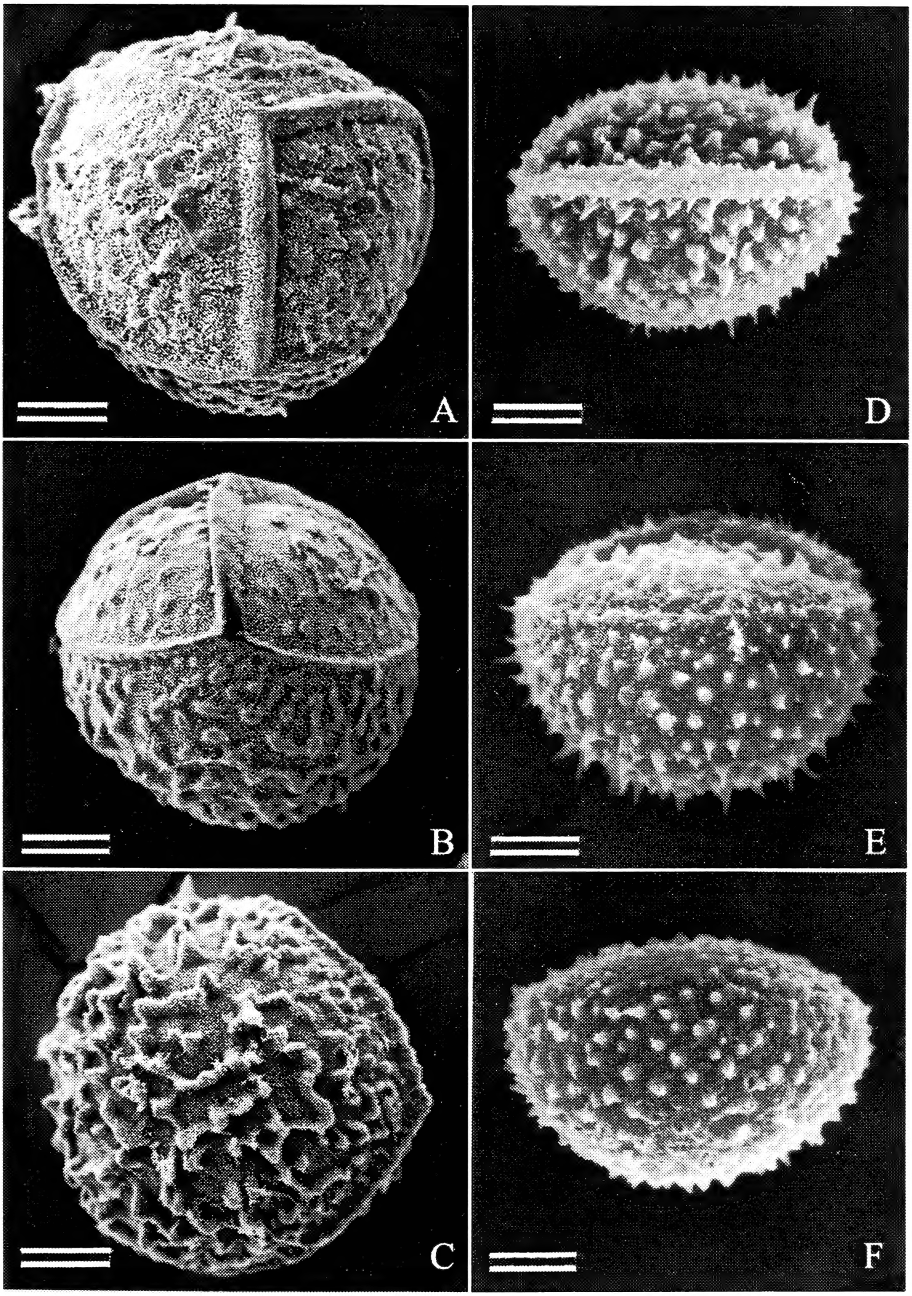


Figure 3. SEM micrographs of mega- and microspores of Korean *Isoetes sinensis* var. *sinensis* (*Miyabe & Takamiya 1*). **A-C**. Megaspores. **D-F**. Microspores. A, D. Proximal view. B, E. Lateral view. C,F. Distal view. Bars = 100μm in A-C. Bars = 10 μm in D-F.

Isoetes sinensis var. *sinensis* is the only tetraploid quillwort known in eastern Asia. The other taxa in this region include diploids (2*n* = 22) *I. asiatica* and *I. taiwanensis* De Vol, hexaploids (2*n* = 66) *I. japonica* and *I. sinensis* var. *coreana*, heptaploid (2*n* =77) *I. michinokuana* M.Takamiya, M.Watanabe & K.Ono, and octaploid (2*n* = 88) *I. pseudojaponica* M.Takamiya, M.Watanabe & K.Ono (Takamiya, 1999; Takamiya *et al.*, 1994, 1997). *Isoetes sinensis* var. *sinensis*, therefore, may be a key taxon for the clarification of speciation in eastern Asian quillworts.

The muri in *I. sinensis* var. *sinensis* are variable, ranging from partly anastomosed, to sinuous and branched to unbranched, short and straight isolated. The megaspore muri of the Cheju Island population are lower and shorter than those of Chinese and Japanese material (Nasu & Seto, 1986; Watanabe *et al.*, 1996).

The megaspore surface morphology of the present materials is similar to that of *Isoetes taiwanensis*, an endemic diploid of Taiwan. Except for size, there are no substantial differences apparent in the microspore morphology between *I. sinensis* var. *sinensis* and *I. taiwanensis*. SEM studies by Britton and Brunton (1991) and Huang *et al.* (1992) demonstrate that megaspore muri of *I. taiwanensis* are low and isolated, or rarely connected. This spore ornamentation pattern would be categorized as tuberculate to rugulate (Hickey, 1986). Proximal and lateral megaspores views of the Cheju Island *I. sinensis* var. *sinensis* population (Fig. 3A and 3B) are hardly distinguishable from those of *I. taiwanensis* from Figures 1c-f in Britton and Brunton (1991) and from Figures 4d and 4e in Huang *et al.* (1992). For analysis of speciation patterns in eastern Asian *Isoetes*, therefore, further phylogenetic comparisons between *I. sinensis* and *I. taiwanensis* would appear to be a potentially important area of research.

ACKNOWLEDGEMENTS

I would like to thank Mitsuru Miyabe of Kobe University for collecting and sending the Korean *Isoetes* material and Daniel F. Brunton, Canada, for valuable comments and linguistic help on an early version of this manuscript. I acknowledge with pleasure the assistance of Tadao Matsusaka and Takao Yamaguchi of Kumamoto University in obtaining SEM pictures and of the curator of PE for examination of herbarium specimens. Stay and investigations at PE were partly supported by the Grant-in-Aid for Scientific Research Program (A) No. 10044209 (the representative Professor Katsuhiko Kondo, Hiroshima University) by the Ministry of Education, Science, Sports and Culture, Japan.

REFERENCES

BRITTON, D.M. 1991. A hybrid *Isoetes*, *I.* x*harveyi*, in northeastern North America. Canad. J. Bot. 69: 634-640.

BRITTON, D.M. & BRUNTON, D.F. 1989. A new *Isoetes* hybrid (*Isoetes echinospora* x *riparia*) for Canada. Canad. J. Bot. 67: 2995-3002.

BRITTON, D.M. & BRUNTON, D.F. 1991. The spores and affinities of *Isoetes taiwanensis* (Isoetaceae: Pteridophyta). Fern Gaz. 14: 73-81.

BRITTON, D.M. & BRUNTON, D.F.1992. *Isoetes* x*jeffreyi*, hyb.nov., a new *Isoetes* (*Isoetes macrospora* x *Isoetes riparia*) from Quebec, Canada. Canad. J. Bot. 70: 447-452.

BRITTON, D.M. & BRUNTON, D.F. 1993. *Isoetes* x*truncata*: a newly considered pentaploid hybrid from western North America. Canad. J. Bot. 71: 1016-1025.
BRITTON, D.M. & BRUNTON, D.F. 1995. *Isoetes* x*marensis*, a new interspecific hybrid from western Canada. Canad. J. Bot. 73: 1345-1353.
BRITTON, D.M. & BRUNTON, D.F. 1996. *Isoetes* x*pseudotruncata*, a new triploid hybrid from western Canada and Alaska. Canad. J. Bot. 74: 51-91.
BRITTON, D.M., BRUNTON, D.F. & TALBOT, S.S. 1999. *Isoetes* in Alaska and the Aleutians. Amer. Fern J. 89: 133-141.
BRITTON, D.M. & GOLTZ, J.P. 1991. *Isoetes prototypus* a new diploid species from eastern Canada. Canad. J. Bot. 69: 277-281.
BRUNTON, D.F. & BRITTON, D.M. 1991. *Isoetes* x*hickeyi* (Isoetaceae: Pteridophyta) in Canada. Brit. Fern Gaz. 14: 17-23.
BRUNTON, D.F. & BRITTON, D.M. 1996a. The status, distribution, and identification of Georgia quillwort (*Isoetes georgiana*; Isoetaceae). Amer. Fern J. 86: 105-113.
BRUNTON, D.F. & BRITTON, D.M. 1996b. Taxonomy and distribution of *Isoetes valida*. Amer. Fern J. 86: 16-25.
BRUNTON, D.F. & BRITTON, D.M. 1997. Appalachian quillwort (*Isoetes appalachiana*, sp. nov.; Isoetaceae), a new pteridophyte from the eastern United States. Rhodora 99: 118-133.
BRUNTON, D.F. & BRITTON, D.M. 1998. *Isoetes microvela* (Isoetaceae), a new quillwort from the coastal plain of the southeastern United States. Rhodora 100: 261-275.
BRUNTON, D.F. & BRITTON, D.M. 1999. Rush quillwort (*Isoetes junciformis*, sp. nov.), a new pteridophytes from southern Georgea. Amer. Fern J. 89: 187-197.
BRUNTON, D.F., BRITTON, D.M. & TAYLOR, W.C. 1994. *Isoetes hyemalis*, sp. nov. (Isoetaceae): A new quillwort from the southeastern United States. Castanea 59: 12-21.
BRUNTON, D.F., BRITTON, D.M. & WIEBOLDT, T.F. 1996. Taxonomy, identity, and status of *Isoetes virginica* (Isoetaceae). Castanea 61: 145-160.
BRUNTON, D.F. & TAYLOR, W.C. 1990. *Isoetes* x*brittonii* hyb.nov. (Isoetaceae): a naturally occurring hybrid (*I. engelmannii* x *I. riparia*) in the eastern United States. Amer. Fern J. 80: 82-89.
CHUNG, Y.H. & CHOI, H.K. 1986. *Isoetes coreana*, a new species from Korea. Korean J. Pl. Taxon. 16: 1-12 (in Korean).
DEVOL, C.E. 1972. *Isoetes* found on Taiwan. Taiwania 17: 1-7.
HICKEY, R.J. 1986. *Isoetes* megaspore surface morphology: nomenclature, variation, and systematic importance. Amer. Fern J. 76: 1-16.
HUANG, T.-C., CHEN, H.-J. & LI, L.-C. 1992. A palynological study of *Isoetes taiwanensis* DeVol. Amer. Fern J. 82: 142-150.
IWATSUKI, K. 1995. Isoetaceae. In: IWATSUKI, K., YAMAZAKI, T., BOUFFORD, D.E. & OHBA, H. (Eds). Flora of Japan I. Kodansha Ltd., Tokyo, p. 18.
KOTT, L.S. & BRITTON, D.M. 1983. Spore morphology and taxonomy of *Isoetes*. Canad. J. Bot. 61: 3140-3163.
LEE, T.B. 1989. Illustrated flora of Korea. Hyangmunsa, Seoul (in Korean).
LEE, W.T. 1996. Coloured standard illustrations of Korean plants. Academy Seojeog, Seoul (in Korean).
MARSDEN, C.R. 1979. Morphology and taxonomy of *Isoetes* in Australasia, India, north-east and south-east Asia, China and Japan. Department of Botany, University of Adelaide, Adelaide (PhD thesis).

MUSSELMAN, L.J. & KNEPPER, D.A. 1994. Quillworts of Virginia. Amer. Fern J. 84: 48-68.
MUSSELMAN, L.J., BRAY, R.D. & KNEPPER, D.A. 1996. *Isoetes* x*bruntonii* (*Isoetes engelmannii* x *I. hyemalis*), a new hybrid quillwort from Virginia. Amer. Fern J. 86: 8-15.
MUSSELMAN, L.J., BRAY, R.D. & KNEPPER, D.A. 1997. *Isoetes* x*carltaylorii* (*Isoetes acadiensis* x *Isoetes engelmanii*), a new interspecific quillwort hybrid from the Chesapeake Bay. Canad. J. Bot. 75: 301-309.
NASU, T. & SETO, K. 1986. Spore morphology of Japanese pteridophytes. Part I. Osaka Mus. Nat. Hist. (Special Pub.) 16-18: 1-42, with 174 plates.
PALMER, T.C. 1927. A Chinese *Isoetes*. Amer. Fern J. 17: 111-113.
PANIGRAHI, G. 1981. Systematics of the genus *Isoetes* L. (Isoetaceae) in India. Biol. Mem. 6: 129-138.
PARK, M. 1942. *Isoetes japonica* in Korea. J. Jap. Bot. 18: 547 (in Japanese).
SRIVASTAVA, G.K. 1998. Isoetaceae in India: morphology and taxonomy. Indian Fern. J. 15: 165-177.
SRIVASTAVA, G.K., PANT, D.D. & SHUKLA, P.K. 1993. The genus *Isoetes* L. in India. Amer. Fern J. 83: 105-119.
TAKAMIYA, M. 1999. Natural history and taxonomy of *Isoetes* (Isoetaceae). Acta Phytotax. Geobot. 50: 101-138 (in Japanese).
TAKAMIYA, M., WATANABE, M. & ONO, K. 1994. Biosystematic studies on the genus *Isoetes* in Japan. I. Variations of the somatic chromosome numbers. J. Plant Res. 107: 289-297.
TAKAMIYA, M., WATANABE, M. & ONO, K. 1996. Biosystematic studies on the genus *Isoetes* (Isoetaceae) in Japan. II. Meiotic behavior and reproductive mode of each cytotype. Amer. J. Bot. 83: 1309-1322.
TAKAMIYA, M., WATANABE, M. & ONO, K. 1997. Biosystematic studies on the genus *Isoetes* (Isoetaceae) in Japan. IV. Morphology and anatomy of sporophytes, phytogeography, and taxonomy. Acta Phytotax. Geobot. 48: 89-122.
TAYLOR, W.C. & LUEBKE, N.T. 1988. *Isoetes* x*hickeyi*: a naturally occurring hybrid between *I. echinospora* and *I. macrospora*. Amer. Fern J. 78: 6-13.
TAYLOR, W.C., LUEBKE, N.T., BRITTON, D.M., HICKEY, R.J. & BRUNTON, D.F. 1993. Isoetaceae. In: EDITORIAL COMMITTEE (Eds). Flora of North America 2. Oxford University Press, Oxford, pp 64-75.
TAYLOR, W.C., LUEBKE, N.T.& SMITH, M.B. 1985. Speciation and hybridisation in North American quillworts. Proc. Roy. Soc. Edinb. 86B: 259-263.
TRYON, A.F. & LUGARDON, B. 1990. Spores of the Pteridophyta. Springer-Verlag, New York.
WALTER, K.S. & GILLETT, H.J. 1998. (Eds). 1977 IUCN Red List of Threatened Plants. IUCN Publications Services Unit, Cambridge.
WATANABE, M., TAKAMIYA, M., MATSUSAKA, T. & ONO, K. 1996. Biosystematic studies on the genus *Isoetes* (Isoetaceae) in Japan. III. Variability within qualitative and quantitative morphology of spores. J. Plant Res. 109: 281-296.
WU, S.-W. & CHING, R.-C. 1991. Fern families and genera of China. Science Press, Beijing

CYTOLOGY OF SOME FERNS FROM THE NILGIRIS, SOUTH INDIA – IV

S.S. BIR [1] & V. IRUDAYARAJ[2]

[1]Department of Botany, Punjabi University, Patiala 147 002, India
[2]Environmental Resources Research Centre, Pomallioorkonam, Peroorkada, Thiruvananthapuram, Kerala - 695 005, India

Key words : apogamous, cytology, Nilgiris (south India), polyploidy, sexual.

ABSTRACT

Chromosomal analysis of eleven species (14 cytotypes) of ferns from the Nilgiris, south India has been made. All the species, except for *Adiantum raddianum* have been cytologically investigated for the first time from the Nilgiris. *Microsorum membranaceum* with n = 72 is a new cytotype for south India.

Diploid (n = 57), tetraploid (n = 114) and octoploid (n = 228) sexual cytotypes are recorded for *Adiantum raddianum* from the Nilgiris. Additionally one sterile octoploid cytotype is also recorded. Colour variation of the sori in *Trigonospora caudipinna* has been observed for the first time and it has been compared with another cyto-morphotype for Kothayar Hills, south India. From 14 cytotypes of 11 species presently analysed, six cytotypes are diploids, four are tetraploids, two are octoploids, one is 16-ploid and another one is triploid apogamous. Sexual cytotypes account for 85.71% while the incidence of polyploidy amongst the recorded cytotypes is 42.86%.

INTRODUCTION

Work on the cytology of ferns of the Nilgiris, south India was started in 1992 and the present paper reporting chromosomal analysis results for 11 species is a continuation of our earlier three papers ((lrudayaraj, Bir & Manickam, 1993; lrudayaraj & Bir, 1994; Bir, lrudayaraj & Manickam, 1996) in which cytological information for 32 species was given.

MATERIALS AND METHODS

Young, developing sporangia from fertile frond portions of wild plants were squashed in acetocarmine after being fixed in 1:3:6 mixture of chloroform, glacial acetic acid and 100% ethyl alcohol for 24 hours and then preserved in 95% ethyl alcohol. Meiotic chromosomes were observed in several cells for establishing the correct counts. In two cases mitotic chromosomes were also counted. Vouchers are deposited in the herbaria of St. Xavier's College, Palayarnkottai, Tamilnadu (XCH) and Enviommental Resources Research Centre, Thiruvanamthapuram (ERRC), both in south India. Details of exact localities for material of various species are set out in Table 1.

TABLE I. Chromosome numbers of some ferns* from the Nilgiris south India.
* First report from the Nilgiris except Sp. No. 3b (see text for reports from other regions). **During meiosis in SMCs multivalents, bivalents and univalents are noticeable and the resultant spores are bad and abortive. +First report from India. ++First report from south India.

Sp. No.	Name of the species	Locality & altitude	Voucher number/s	Chromosome number	Ploidy & reproduction
1	***Parahemionitis arifolia*** (Burm.f.) Panigrahi	Sholur, 1,500 m	ERRC 4160	n='2n'=90 (Fig. 1A)	triploid apogamous
2	*Adiantum lunulatum* Burm.	Keelnadugani 1,300 m	ERRC 4292	n=60	tetraploid sexual
3	*Adiantum raddianum* C.Presl	(a) Kothagiri 1,800 m	ERRC 4214	n=57	tetraploid sexual
		Kothumundi 1,800 m	ERRC 4146	n=57	tetraploid sexual
		(b) Nadugani 1,300 m	ERRC 4198	n=114	octoploid sexual
		(c) Kothagiri 1,800 m	ERRC 4218	2n=228 (meiosis irregular)	octoploid sterile**+
		(d) Sholur 1,500 m	ERRC 4227	n=228 (Fig. 1B)	16-ploid sexual+
4	*Nephrolepis multiflora* (Roxb.) F..M. Jarrett	Keelnadugani 1,300 m	ERRC 4188	n=41	diploid sexual
5	*Stegnogramma pozoi* (Lagasca) K.lwats.	Sholur 1,500 m	ERRC 4248	n=72	tetraploid sexual
6	*Pronepherium articulatum* (Houlston & T. Moore) Holttum	Keelnadugani 1,300 m	ERRC 4204	n=36	diploid sexual
7	*Trigonospora caudipinna* (Ching) Sledge	Nadugani-Gena pool Forest	XCH 1589	n=36 (Fig. 4A)	diploid sexual
8	*Diplazium polypodioides* Blume (non *Diplazium polypodioides* auct. of the Himalaya)	Keelnadugani 1,300 m	ERRC 4205	n=41	diploid sexual

TABLE I cont. Chromosome numbers of some ferns* from the Nilgiris south India.
* First report from the Nilgiris except Sp. No. 3b (see text for reports from other regions). **During meiosis in SMCs multivalents, bivalents and univalents are noticeable and the resultant spores are bad and abortive. +First report from India. ++First report from south India.

Sp. No.	Name of the species	Locality & altitude	Voucher number/s	Chromosome number	Ploidy & reproduction
9	*Diplazium esculentum* (Retz.) Sw.	Keelnadugani 1,300 m	ERRC 4203	n=41	diploid sexual
10	*Asplenium laciniatum* D.Don	Sholur 1,500 m	ERRC 4177	n=36	diploid sexual
11	*Microsorum membranaceum* (D.Don) Ching	Keelnadugani 1,300 m	ERRC 4207	n=72 (Fig. 4C)	tetraplod sexual++

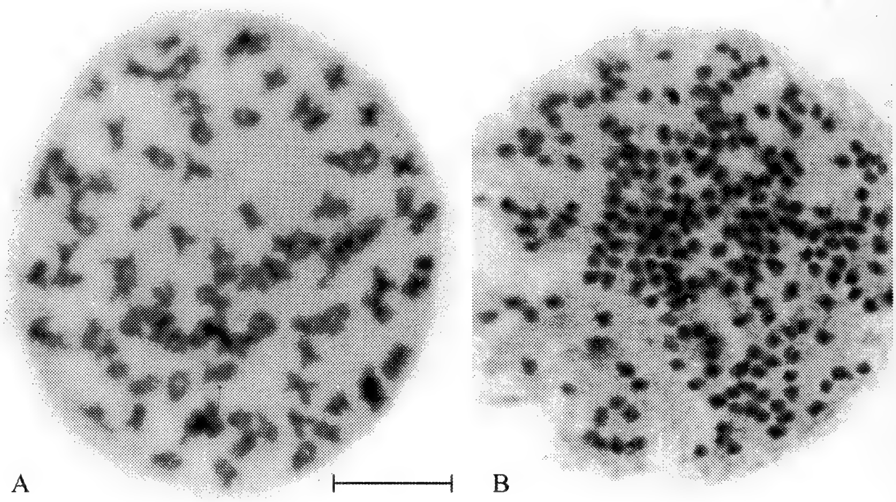
RESULTS AND DISCUSSION

Information about the recorded chromosome numbers, level of ploidy and mode of reproduction for the 14 taxa (11 species) analysed is provided in Table 1. There is only one triploid apogamous fern and one octoploid sterile fern while all the rest are characterised by sexual reproduction with the production of 64 normal spores per sporangium. These spores look well-filled, healthy and functional. Amongst the sexual taxa are included six diploids, four tetraploids, one octoploid and one 16-ploid (Table 1).

I. Parahemionitis arifolia (Burm.f.) Panigrahi, Indian Fern J. 9(1-2):224. 1992 (1993), Amer. Fern J. 83(3):90. 1993.
Hemionitis arifolia (Burm.f.) T. Moore

This common fern of Tamilnadu and Kerala States of south India grows abundantly in the Nilgiris at 1,000-2,000m altitude on fully exposed roadside rocks or in forest clearings in full or partial shade. Very often vegetatively produced plantlets are seen in the notch or deep sinus of the sterile leaf where the petiole joins the lamina.

Sholur material is triploid and apogamous as it shows 90 'bivalents' in spore mother cells (SMCs) from 8-celled sporangia (Fig. I A) and each of such sporangia has extremely regular meiosis producing 32 viable spores. On the other hand, the SMCs forming 16-celled sporangia show highly irregular meiosis with usually 30 bivalents +30 univalents (variations in their number are not infrequent) giving 2n= 90. The ratio of 8-celled and 16-celled sporangia per unit fertile area is usually 5:1 but different populations of the species show highly variable ratios not only from the Nilgiris but also from elsewhere since the number of 8-celled and 16-celled sporangia depends upon the degree to which the apogamy has been established. This triploid apogamous fern is extremely common in south Indian mountains because of vegetative propagation (Bir & lrudayaraj, 1991:159-160, Fig. 1).



The majority of the reports for the species pertain to its triploid apogamous

Figure 1. Meiosis in spore mother cells. Scale bar = 20μm for A-B. **A.** *Parahemionitis arifolia* (Burm.f.) Panigrahi, with n='2n'=90. **B.** *Adiantum raddianum* C.Presl, n=228.

nature with n = '2n' = 90 = 3x (Abraham, Ninan & Mathew, 1962; Ghatak, 1977; Bir & Vasudeva, 1979; lrudayaraj & Manickam, 1987; Manickam & lrudayaraj, 1988) but Mathew (in Fabbri, 1965:689) and Kuriachan & Ninan (1976) recorded it as tetraploid apogamous with n = '2n' = 120. The species exhibits highly variable plant and leaf size because it can grow abundantly on rocks both in fully shaded and partially shaded or even exposed situations along roadsides. Morphological variations are very evident in triploid apogamous plants from the Nilgiris as well as Kothayar Hills. Tetraploid apogamous material was not available for comparision. The origin of these two apogamous cytotypes is still unknown.

2. Adiantum lunulatum Burm. f., Fl. Indica. 235. 1768.
Adiantum philippense L.

This is the most widely distributed fern on the Indian subcontinent, being reported from the Himalaya and western, central, and southern Indian mountains. In the Nilgiris, it is a common occupant of moist shaded situations such as roadside earth cuttings and slopes as well as the crevices of moist rocks and often forms small or large colonies. The triploid apogamous form (n = '2n' = 90) has the widest distribution but diploid sexual (n = 30), diploid apogamous (n ='2n' = 60) and tetraploid sexual (n = 60) forms are also recorded (Bir & Verma, 1989).
The Nilgiris material from Keelnadugani is tetraploid sexual, (n = 60) like the east Himalayan material (Darjeeling: Verma, 1961) and south Indian material (Peermade and Ponmudi, Western Ghats: Abraham, Ninan & Mathew, 1962). The species shows a wide range of morphological variaitons and comparison of the tetraploid sexual from the Nilgiris and triploid apogamous specimens from PUN did not yield any significant morphological differences.

3. Adiantum raddianum C.Presl, Tent. pterid. 158. 1836.
Adiantum cuneatum Langsd. & Fisch.

It commonly grows on stony clearings in fully or partially shaded situations in a broad altitudinal range of 500-1,800 m in the Nilgiris but is very common between 1,500-1,800m. Often this fern is abundant in moist localities of the *sholas.* It provides very interesting results in the fact that three sexual cytotypes (n = 57 = 4x, n = 114 = 8x and n = 228 = 16x) and one sterile cytotype (2n = 228 = 8x) have been encountered from different localities in the Nilgiris (see Table 1). The 8x sexual recorded from Nadugani (1,300 m) confirms our earlier count of n = 114 from Conoor 1,600 m (Bir, lrudayaraj & Manickam, 1996). Assuming basic chromosome numbers of x = 29, 30 for *Adiantum,* cytotypes with n = 57, 114, 228 are all aneuploids. In all probablity, cytotypes with n = 114 and n = 228 are polyploids based on n = 57 and may possibly be autoploid in origin although both form bivalents at meiosis. An autopolyploid origin of tetraploid *Asplenium rutamuraria* L. and tetraploid *A. septentrionale* (L.) Hoffm., both with 72 bivalents was clearly demonstrated by Lovis (1964). Support for an autoploid origin in *Adiantum raddianum* comes from the preliminary RAPD (Random Amplification of Polymorphic DNA) analysis by means of Polymerase Chain Reaction (PCR) undertaken by Dr. Helena Korpelainen (Helsinki) on plants with n= 114. The results indicated that octoploid plants with n = 114 are possibly the autoploids from telraploid plants with n = 57 (pers. comm. to V. lrudayaraj). Taking this clue one could assume that 16-ploid plants with n = 228 (Fig. IB) may also be of autoploid origin from those with n = 114. Earlier reports of the same species or under the name *A. cuneatum* Langsd & Fisch. record n = 57, 2n = 114, 4x (Abraham, Ninan & Mathew, 1962); n = 58, 4x (Ghatak, 1977); n ='2n' = 87, 3x apogamous (Ghatak, 1977); n = 60, 2n=120, 4x (Roy & Sinha, 1961, 1962); n = 60,4x (Bir & Vasudeva, 1979; lrudayaraj & Manickam, 1985); and n = 114, 8x (Manickam, 1984; Bir, lrudayaraj & Manickam, 1996). These indicate the role of 'aneuploidy' at at least the 4x level leading to evolution of an array of chromosome numbers in the ' species' which is polymorphic morphogenetically. The question of the origin of tetraploid plants with n = 57, 58 and 60 is intriguing. It seems possible that there may exist in nature three types of diploid individuals of *A. raddianum* with n = 28, n =29 and n = 30, and diploid individuals with n = 28 and n = 29 produced tetraploid plants with n = 57 through allopolyploidy while diploid plants with n = 29 and n = 30 produced tetraploid plants with n = 58 and n = 60 through autopolyploidy as explained above for 8x and 16x plants.

Bir, lrudayaraj & Manickam (1966) noted that the Nilgiris, Shevaroy and Western Ghats (possibly Yercad) materials of octoploid sexual (n = 114) exactly resemble one another. As far as 4x, 8x and 16x plants and also 8x sterile plants *of A. raddianum* are concerned, they do show some variations in morphology (Figs 2A-B, 3A-B) since there are differences in their habitats. Tetraploid plants grow in fully exposed places on dry soil as solitary plants or forming isolated small colonies. These tend to grow even on exposed rocks. In contrast, the octoploid plants grow along shaded roadsides on wet soil, intermixed with many other ferns, forming large colonies. The association of other ferns with the tetraploid cytotype is very much limited as compared with octoploid plants. The sterile cytotype shares the same habitat of octoploid sexual cytotype. The 16-ploid cytotype grows among or beneath the tea bushes.

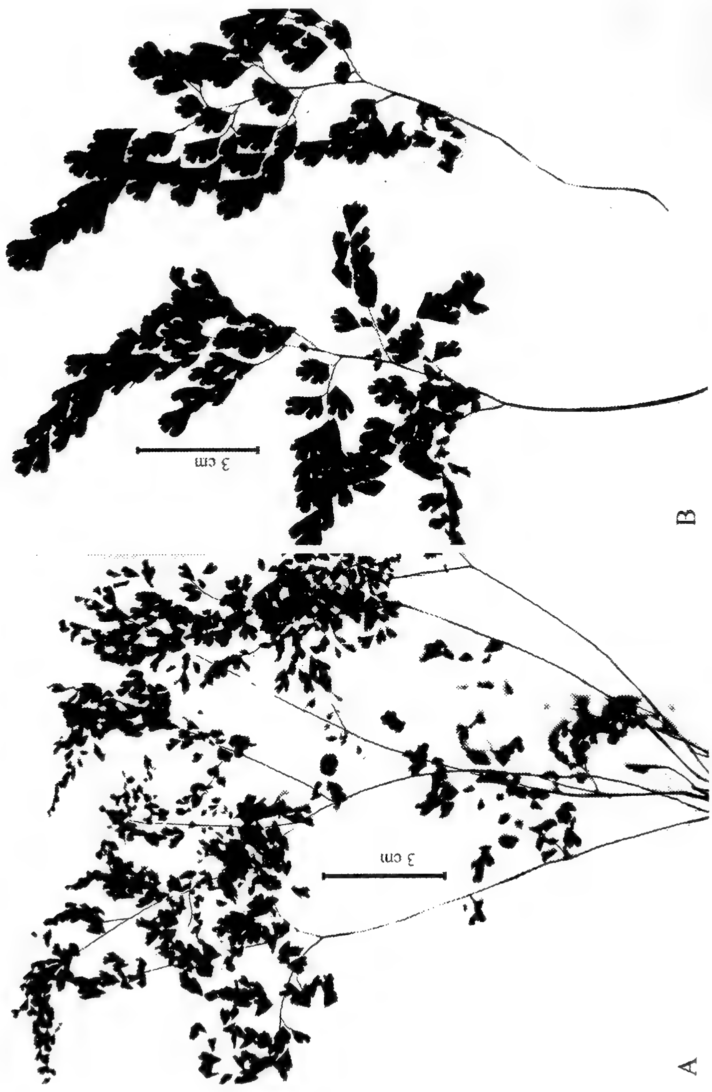


Figure 2. Laminae from vouchers of tetraploid and octoploid sexual cytotypes of *Adiantum raddianum* C.Presl. **A.** ERRC 4214 with n=57. **B.** ERRC 4198 with n=114.

4. Nephrolepis multiflora (Roxb.) F.M.Jarrett ex Morton, Contrib. U.S. Natl. Herb. 38:309.1974
Davallia multiflora Roxb.

It commonly grows in small or large colonies at low altitudes and is at its best in the crevices of rocks or masonry in fully exposed situations. The material from Keelnadugani is diploid sexual with n = 41 while the earlier reports by Kuriachan (1968) for south Indian material indicate the presence of two cytotypes with 2n = 82, 2 x; n = 82, 2n =164, 4x.

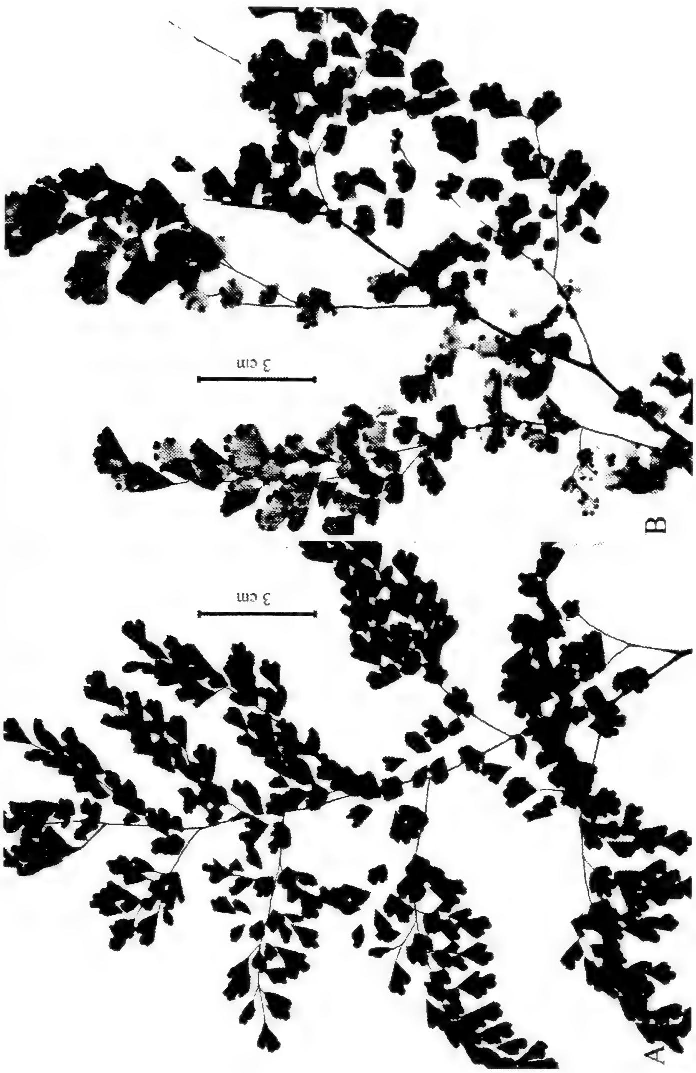


Figure 3. Laminae from vouchers of octoploid sterile and 16-ploid sexual cytotypes of *Adiantum raddianum* C.Presl. **A.** ERRC 4218 with 2n=228 (irregular meiosis). **B.** ERRC 4227 with n=228.

5. Stegnogramma pozoi (Lagasca) K.Iwats., Acta Phytotax. Geobot. 19:124. 1963.
Leptogramma totta J.Sm.

This tetraploid sexual species, exhibiting 72 bivalents in SMCs is a common fern of the Nilgiris growing between 1,200-1,500 m along shaded or partly exposed stream banks in the *shola* forests' interiors or at their edges. The recorded number n = 72 agrees with earlier reports from south India (Palni Hills: Bir & Vasudeva, 1978, 1979; Manickam & lrudayaraj, 1988; Shevaroy Hills: Ghatak, 1977) as well as

western Himalaya (Khullar, Sharma & Singh, 1983). Manton & Sledge (1954) have reported a diploid cytotype (n = 36) from Sri Lanka.

According to Kunze (1851) and Sledge (1981) the Nilgiris plants belong to the variety *mollissima* (Kunze) Sledge. However, lrudayaraj, Manickam & Dominic Rajkumar (1996) suggested that infraspecific division/s in this species cannot be established due to the presence of great morphological variations amongst individuals of different populations form south India.

6. Pronephrium articulatum (Houlston & T.Moore) Holttum, Blumea 20:116.1972.

This rare fern of the Nilgiris was observed a few times between 1,000-1,300 m growing alongside fully shaded small water channels. As in *Pseudocyclosorus tylodes* (Kunze) Ching, the sori are pink in colour. The present material from Keelnadugani is diploid sexual with 36 bivalents in SMCs. The only previous report of cytology from south India is from Anamalais by Manickam & lrudayaraj (1989, 1990). This diploid species possesses a massive ascending rhizome in contrast to the related tetraploid species *Pronephrium triphyllum* (Sw.) Holttum that has a long creeping rhizome (Manickam & lrudayaraj, 1990).

7. Trigonospora caudipinna (Ching) Sledge, Bull. Brit. Mus. (Nat. Hist.) Bot. 8(1):15. 1981.
Lastrea calcarata var. *ciliata* Bedd.

This fern grows well along roadsides as well as inside the forests of the Nilgiris between 750-1,600 m. It is delimited with difficulty from *T. ciliata* (Wall. ex. Benth.) Holttum found at 1,000-1,400 altitude. The basal pinnae are not reduced in *T. caudipinna* wheras three pairs of basal pinnae are progressively reduced in the other species i.e. *T. ciliata.* Also the pinnae lobes are cut down to three- quarters of the way to the costa in the former and in the latter they are cut half-way to the costa. Indusia in both *Trigonospora* species are covered with acicular hairs. Plants from Nadugani-Gena Pool Forest show 36 bivalents in SMCs (Fig. 4A) indicating these to be diploid sexual. Previous reports from south India pertain to diploid sexual (n = 36) from Tirunelveli Hills and Munar (Manickam & lrudayaraj, 1988) and tetraploid sexual (n = 72) from Kothayar Hills (Manickam & lrudayaraj, 1988).

A great degree of variation in morphology of various individuals is exhibited by the species. This manifests itself in the size of the plant, degree of lobing of the pinnae and the amount of pubescence in the south Indian poplulations of the species (Manickam & lrudayaraj, 1992 and the authors' field observations). Variation in soral colour at a young stage has also been observed. The Nilgiri plants exhibit the usual yellowish green sori of the diploid sexual (n = 36) while the tetraploid sexual (n = 72) plants from Kothayar Hills show pink colour of the sori. Cytological status of the Kothayar Hills plants was re-affirmed during the present study also (Fig. 4 B). Chromosomal analysis of another collection from Kallar (ERRC4136), Kerala State, showed that the plants have yellowish green sori and are of diploid sexual status like the Nilgiris plants. There seems to be a correlation between ploidy level and colour of the sori. With the aim of determining the influence of altitude and other enviornmental factors on soral colour, a plant with pink coloured young sori was transplanted from Kothayar 1,100m to Thiruvananthapuram (Trivandrum), 500m altitude. The rhizome produced few fronds within three weeks (though stunted) but with pink coloured sori. But this type of soral colour and ploidy level correlation

needs to be confirmed on the basis of intensive field study at the population level. Both the diploid sexual plants with green coloured sori and the tetraploid sexual plants with pink coloured sori have typically erect rhizomes. However, the 4x plants from Kothayar are characterized by massive rhizomes and are more than a metre in height.

Preliminary Thin Layer Chromatography and High Performance Liquid Chromatography studies (Britto, Manickam & Gopal Krishnan, 1994) on different cytomorphotypes of this species complex indicated an autopolyploid origin of the tetraploid cytotype because of the presence of similar types of band patterns in the two cytotypes.

8. Diplazium polypodioides Blume, Enum. pl. Javae 194. 1828, non *Diplazium polypodioides* auct. of the Himalaya.

True *Diplazium polypodioides* is endemic to south India and Sri Lanka and reports of its occurrence in the Himalaya are erroneous (see Bir & lrudayaraj, 1992). This large-sized terrestrial fern is abundant between 1,000-1,400m altitude and prefers to grow along fully or partially shaded water courses. Often, it may be found in the deforested areas too, but here the plants exhibit stunted growth. It shows 41 bivalents in plants from Keelnadugani (1,300m) and the result is in agreement with the reports of Bir (1965), Manickam (1984) and Manickam & lrudayaraj (1988) from Palni Hills, south India. Sankari Ammal & Bhavanandan (1993) carried out karyotypic analysis and recorded 2n = 82 (2 pairs of M, 12 pairs of m, 14 pairs of sm, 13 pairs of st chromosomes). The identity of the Himalayan fern hitherto named *Diplazium polypodioides* auct. has been established to be *D. frondosum* (Wall. ex C.B. Clarke) Christ which is also diploid sexual, n = 41 (Bir & lrudayaraj, 1992). The tetraploid cytotype (n = 82) attributed to *D. polypodioides* (Sankari Ammal & Bhavanandan, 1990) from lduki, Kerala is in all probability *D. polypodioides* Blume var. *brachylobum* Sledge [*D. brachylobum* (Sledge) Manickam & lrud.]. This is also recorded as a tetraploid sexual from Palni Hills (Manickam, 1984). It is characterised by having secondary pinnae lobed 1/3 - to 1/2 - way to the costa and entire or subentire indusia in contrast to secondary pinnae lobed nearly up to the costa and finely fimbriate indusia in *D. polypodioides* Blume (Bir & Irudayaraj, 1992).

9. Diplazium esculentum (Retz.) Sw., J. Bot. (Schrader) 1801(2):312. 1803.
Hemionitis esculenta Retz., *Anisogonium esculentum* C.Presl

Diplazium esculentum is more commonly found in the open places alongside streams or water courses right from the foot of the Nilgiris and reaching up to 1,500m. The material from Keelnadugani where this fern grows in abundance along a stream in a large colony is diploid sexual (n= 41). All the reports from south India (Abraham, Ninan & Mathew, 1962; Bir, 1965; Ghatak, 1977; Bhavanandan, 1981; Manickam, 1984; Manickam & lrudayaraj, 1988) and elsewhere from India i.e. Himalaya, Parasnath Hills, western India, central India (Bir & Verma, 1989) record it as n = 41, 2n = 82. Bhavanandan & Sankari Ammal (1991) record it as tetraploid sexual with n = 82 from Achancoail, Kerala. The two cytotypes cannot be differentiated on the basis of size or other morphological features because of morphological variation found in the diploid taxon. Small simply pinnate fronds on a short rhizome as well as large sized bipinnate fronds on up to 60 cm erect rhizome have been found to be only diploid in the Himalaya and central India.

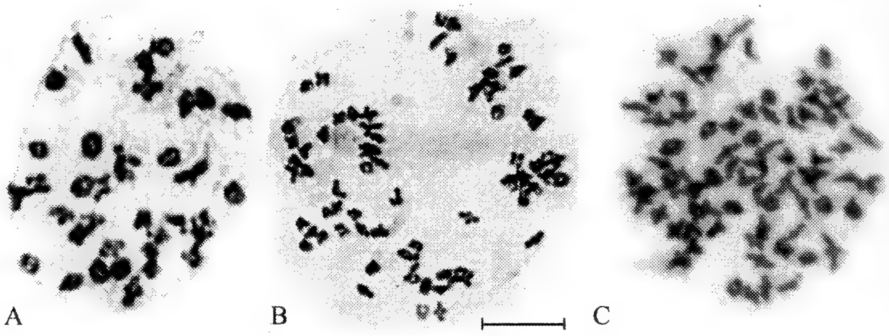


Figure 4. A-C Meiosis in spore mother cells. Scale bar = 20µm for A-C. **A.** *Trigonospora caudipinna* (Ching) Sledge, diploid cytotype showing n=36 (XCH 1589). **B.** *Trigonospora caudipinna* (Ching) Sledge, tetraploid cytotype from Kothayar Hills showing n=72. Confirmed from counting 144 chromosomes in the root tip. **C.** *Microsorum membranaceaum* D.Don, n=72.

10. Asplenium laciniatum D.Don, Prod. fl. Nepal. 8. 1825.
Asplenium varians Wall. ex. Hook. & Grev.

This small-sized, herbaceous spleenwort is a very rare fern of south India but was described by R.H. Beddome (1864: t.129) in *Ferns of Southern India* as *Asplenium varians.* It grows on moist, shaded substrate between 1,200-1,500m and can easily be overlooked because of it being intermingled with grasses as it grows on shaded rock boulders.

Hitherto, the name *A. varians* Wall. ex Hook. & Grev. had long been accepted for this fern but in 1973 C.V. Morton observed "*It is indeed unfortunate, that the application of the name A. laciniatum D.Don must be changed, but I see no alternative*". The herbarium sheet of the holotype of *A. laciniatum* D. Don at BM has a number of plants numbered as "1", "2" and "3". The three plants numbered "2"' are on the left centre and are collected from Nepal by Wallich in 1817 and this information is the same as given by Hooker & Greville (1830: t.178) for their *Asplenium varians.* These specimens agree with Hooker & Greville's figure as verified by the author during his visit to BM in 1980 by examining the holotype. Morton (1973) is sure that the true *A. laciniatum* described by D. Don (1825) is identical with the plants described as *A. varians* Hook. & Grev. as referred to above. Thus on the basis of holotype identity and priority of publication dates, *A. varians* becomes a synonym of *A. laciniatum* (see also Singh & Bir, 1989) and the Himalayan plant so commonly called *A. laciniatum* D. Don is named by Morton (1973) as *A. gueinzianum* Mett., though tentatively. The late Professor T. Reichstein from Basel, Switzerland was opposed to this name change (pers. comm. to S.S. Bir).

This rare fern grows on small stones on the forest floor and the present record of diploid sexual with n = 36 is in conformity with the previous reports from south India: Kodaikanal (Bir, 1965), Eastern Ghats (Manickam & Irudayaraj, 1988; Ghatak, 1977) and Western Ghats (Kuriachan, 1978). Diploid sexual cytotype is also recorded from Palni Hills (Bir, 1965). Both diploid (n = 36) and tetraploid (n = 72)

cytotypes are recorded from the Himalaya; eastern as well as western region (Bir & Verma, 1989). Comparision of the diploid and tetraploid sexual cytotypes from Sikkim State in the eastern Himalaya (2 x: PUN 2000, 4 x: PUN 1997, 1999) do not show any pronounced morphological differences. Only the extremes are distinct and the detection of various cytotypes in the field is very difficult. The stomata and epidermal cells are not much different. However, the 4x plants may show larger size of the lamina, greater number of pinnae (also larger), larger acroscopic pinnae, greater number of annulus cells per sporangium and slightly larger sized spores as compared with the diploid plants but size ranges sometimes do overlap. Kodaikanal diploid plants (PUN 4795) are not in any way morphologically different from the Himalayan counterparts (PUN 641-643, 2000, 2730,2731, 2840, 4180, 5085, 5086) as investigated by S.S. Bir during the 1950s and the 1960s. It is interesting to point out that recently only 4x sexual plants are recorded by Bir (1994) and Bir, lrudayaraj & Singh (1994) from Kulu, Simla, Mussoorie-Chakrata, Almora and Pithoragrah region in the western Himalaya.

11. Microsorum membranaceum (D. Don) Ching, Bull. Fan. Mem. Inst. Biol. (Bot.) 4:293-352. 1933.

The simple leaved polypod *Microsorum membranaceum* (D. Don) Ching is an occupant of either shaded boulders or the bases of forest tree trunks but is fairly rare in south Indian forests as well as the Nilgiris. The fronds hang majestically from shaded rocks alongside forest paths. The epiphytic plants from Keelnadugani show 72 bivalents in SMCs (Fig. 4 C). So far only the diploid cytotype ($n = 36$) is recorded from south India (Kuriachan, 1968; Manickam, & lrudayaraj, 1998) and the present report is the first record of tetraploid plants from the Nilgiris. From the Himalaya and central India only the diploid sexual, ($n = 36$, $2n = 72$) is recorded (Bir & Verma, 1989) although from Parasnath Hills numbers recorded are $n = 37$, $2n = 74$ (Bir & Verma, 1989). However, from western India Mahabale & Kamble (1981) record the tetraploid with $n = 72$. Both the cytotypes are morphologically indistinguishable from each other. Himalayan fronds varying between 20-100 cm in length all have diploid status.

CONCLUDING REMARKS

Finally, it may be pointed out that so far cytological results have been obtained from the Nilgiris for 42 fern species (cf. Bir, lrudayaraj & Manickam, 1996 and the present investigations). An analysis shows that amongst these there are 18 diploid sexual, five triploid apogamous, 16 tetraploid sexual, two octoploid sexual and one 16-ploid sexual species. The incidence of polyploidy comes to 57.15% and apogamy is 11.90%. Additionally, there are three cytotypes (4x, 8x sterile and 16x) in the case of *Adiantum raddianum* (see Species No. 3 in text and Table I) and overall polyploid taxa are 60% and hybrids including apomicts are 13.33%. Bir (1973) presented a total chromosomal analysis of south Indian Pteridophytes with 56.9% polyploid taxa and the highest grade of recorded polyploidy being at 8-ploid level. For the Nilgiris ferns that have so far been chromosomally analysed, the incidence of polyploidy is nearly the same but the highest grade of polyploidy is at the 16-ploid level in case of two species, namely *Trichomanes schmidianum* Zenker ex Taschn. (Bir, lrudayaraj & Manickam, 1996) and *Adiantum raddianum* C.Presl (the present investigations).

It may be noted that amongst the fern species dealt with here. *Adiantum*

lunulatum Burm. is used in Ayurvedic and Unani system of medicine (Henry, Hosagoudar & Kumar, 1996). Several cytotypes are now known for this fern. This is also the case with several other fern species which are used in Ayurveda. With the availability of a variety of cytotypes for medicinal ferns in India, it is essential to locate the suitable cytotype for determining the maximum efficacy of the fern drugs.

ACKNOWLEDGEMENTS

S.S. Bir thanks the Indian National Science Academy, New Delhi for financial assistance under the Senior Scientist Scheme. V. lrudayaraj wishes to thank CSIR, New Delhi for the award of a Senior Research Associateship. We wish to record our appreciation and gratitude to the Director, Envionmiental Resources Research Centre, Thinivananthapuram for laboratory facilities and to Dr. Helena Korpelainen (Helsinki) for undertaking RAPD analysis on the 8-ploid cytotype of *Adiantum raddianum.*

REFERENCES

ABRAHAM, A., NINAN, C.A. & MATHEW, P.N. 1962. Studies on the cytology and phylogeny of the pteridophytes VII. Observations on one hundred species of south Indian ferns. J. Indian Bot. Soc. 41:339-421.

BEDDOME, R.H. 1864. The ferns of southern India, fasc. II - ult. (tab. 124-271). Gantz Brothers, Madras.

BHAVANANDAN, K.V. 1981. Studies on the cytology of south Indian Aspidiaceae. Cytologia 41:195-206.

BHAVANANDAN, K.V. & SANKARI AMMAL, L. 1991. Cytological investigations of family Aspidiaceae (sensu Copeland) from south India. Indian Fern J. 8:78-86.

BIR, S.S. 1965. Chromosome numbers in ferns from Kodaikanal, south India. Caryologia 18:107-115.

BIR, S.S. 1973. Cytology of Indian pteridophytes. In: NAIR, P.K.K., GROVER, R.K. & VERGHESE, T.M. (Eds) Glimpses Pl. Res. 1:28-119. Vikas Publishing House, New Delhi.

BIR, S.S. 1994. Biosystematics of ferns: Himalayan asplenioid and athyrioid ferns in retrospect. In: SARMA, T.A., SANINI, S.S., TRIVEDI, M.L. & SHARMA, M. (Eds). Current researches in plant sciences, pp. 105-108. Bishen Singh Mahendra Pal Singh, Dehra Dun.

BIR, S.S. & IRUDAYARAJ, V. 1991. Vegetative buds in *Hemionitis arifolia* (Burm.) Moore. Indian Fern J. 8:159-160.

BIR, S.S. & IRUDAYARAJ, V. 1992. Taxonomy of *Diplazium polypodioides* complex in India. Indian Fern J. 9: 188-203.

BIR, S.S., IRUDAYARAJ, V. & MANICKAM, V.S. 1996. Cytology of some ferns from the Nilgiris, south India III. Fern Gaz. 15:141-149.

BIR, S.S., IRUDAYARAJ, V. & SINGH, S. 1994. Biosystematic studies on the asplenioid and athyrioid genera from the Himalayas: results of chromosomal analysis on population basis. Indian Fern J. 11:82-88.

BIR, S.S. & VASUDEVA, S.M. 1978. In: IOPB Chromosome number report LXII. Taxon 27:519-535.

BIR, S.S. & VASUDEVA, S.M. 1979. Cytological studies in some ferns of Kodaikanal (south India). In: BIR, S.S. (Ed.) Recent researches in plant sciences, pp. 221-228. Kalyani Publishers, New Delhi.

BIR, S.S.. & VERMA, S.C. 1989. Chromosome atlas of Indian pteridophytes. pp. i-xviii, 1-129. Department of Environment & Forests, Government of India, New Delhi. (Project Report).

BRITTO, J.D MANICKAM, V.S. AND GOPALKRISHNAN, S. 1994. High Performance Liquid Chromatographic (HPLC) studies on the species of Thelypteridaceae of the western Ghats of south India. Acta. Bot. Indica 22:161-163.

DON, D. 1825. Prodromus florae Nepalensis. J.Gale, London.

FABBRI, F. 1965. Secondo supplemento alle tavole chromosomiche delle Pteridophyta di Alberto Chiarugi. Caryologia 18:675-731.

GHATAK, J. 1977. Biosystematic survery of pteridophytes from Shevaroy Hills, south India. Nucleus (Calcutta) 20: 105-108.

HENRY, A.N., HOSAGOUDAR, V.B. & KUMAR, R. 1996. Ethno-medico botany of southern Western Ghats of India. In: JAIN, S.K. (Ed.) Ethnobiology in Human Welfare, pp. 173-180. Deep Publications, New Delhi.

HOOKER, W.J. & GREVILLE, R.K. 1827 - 1831. Icones Filicum - Vols. 1-2, Treuttel & Würtz, Treuttel fil. & Richter, London.

IRUDAYARAJ, V. & BIR, S.S. 1994. Cytology of some ferns from the Nilgiris, south India. II. Fern Gaz. 14:301-312.

IRUDAYARAJ, V., BIR, S.S. & MANICKAM, V.S. 1993. Cytology of ferns from the Nilgiris, south India. Fern Gaz. 14:161-170.

IRUDAYARAJ, V. & MANICKAM, V.S. 1985. In: LÖVE, A. (Ed.) Chromosome number reports XCI. Taxon 35 : 404-410.

IRUDAYARAJ, V. & MANICKAM, V.S. 1987. In: BIR, S.S. (Ed.) SOCGI Plant Chromosome Number Report IV. J. Cytol. Genet. 22:156-163.

IRUDAYARAJ, V., MANICKAM, V.S. & DOMINIC RAJKUMAR, S. 1996. Studies on intraspecific variation in south Indian ferns III. Cytomorphology of *Stegnogramma pozoi* (Lag.) K.lwats. Thaiszia 5:111-119.

KHULLAR, S.P., SHARMA, S.S. & SINGH, P. 1983. The Thelypteridaceae of W. Himalayas. Nova Hedwigia 38:617-667.

KURIACHAN, P.I. 1968. Cytological observations on some south Indian ferns. Cytologia 32:500-506 (vol. 32 Nos. 3 & 4 of 1967 issued Sept. 25, 1968).

KURIACHAN, P.I. 1978. Cytology of some south Indian ferns. Int. Quart. J. Pl. Sci. Res. 5:53-58.

KURIACHAN, P.I. & NINAN, C.A. 1976. Cytological evolution in the fern family Pteridaceae (*sensu* Copeland). Aspects Pl. Sci. 1:127-150.

KUNZE, G. 1851. Filices Nilagineae. Linnaea 24:239-299.

LOVIS, J.D. 1964. Autopolyploidy in *Asplenium*. Nature 203:324-325.

MAHABALE, T.S. & KAMBLE, S.Y. 1981. Cytology of ferns and other pteridophytes of western India. Proc. Indian Natl. Sci. Acad., B. 47:260-278.

MANICKAM, V.S. 1984. Cytology of thirty species of ferns from the Palni Hills (south India). Cytologia 49:49-59.

MANICKAM, V.S. & IRUADAYARAJ, V. 1988. Cytology of ferns of the Western Ghats, south India, pp. 1-81. Today & Tomorrow's Printers & Publishers, New Delhi.

MANIGKAM, V.S. & IRUADAYARAJ, V. 1989. Corrections to the cytology of ferns of Western Ghats. Indian Fern J. 6:131-132.

MANICKAM, V.S. & IRUADAYARAJ, V. 1990. Thelypteridaceae of the Western Ghats, south India. Indian Fern. J. 7:100-117..

MANICKAM, V.S. & IRUADAYARAJ, V. 1992. Pteridophyte flora of the Western Ghats, south India, pp. i-x, 1-653. B.I. Publication Ltd., New Delhi.

MANTON, I. & SLEDGE, W.A. 1954. Observations on the cytology and taxonomy of the pteridophytic flora of Ceylon. Philos. Trans., Ser. B. 238:127-183.

MORTON, C.V. 1973. Studies on fern types II. Contr. U. S. Nat. Herb. 38:215-281.

ROY, R.P. & SINHA, B.M.B. 1961. Meiotic studies in the genus *Adiantum.* Caryologia 14:413-426,

ROY, R.P. & SINHA, B.M.B. 1962. Cytotaxonomic studies in the genus *Adiantum.* In: MAHESHWARI, P., JOHN, B.M. & VASIL, I.K. (Eds) Proceedings Summer School in Botany, Darjeeling. pp. 349-362. Council of Scientific & Industrial Research, New Delhi.

SANKARI AMMAL, L. & BHAVANANDAN, K.V. 1993. Karyomorphological studies on three species of *Diplazium* Swartz. Indian Fern. J. 10:30-34.

SANKARI AMMAL, L. & BHAVANANDAN, K.V. 1990. A note on the cytology of a tetraploid cytotype of *Diplazium polypodioides* Bl. from ldukki (Kerala), south India. Indian Fern. J. 7:131-132.

SINGH, Y. & BIR, S.S. 1989. Distribution, ecology and phytogeography of asplenioid ferns of India. Indian Fern J. 6:268-284.

SLEDGE, W.A. 1981. The Thelypteridaceae of Ceylon. Bull. Brit. Mus. (Nat. Hist). Bot. 8:1-54.

VERMA, S.C. 1961. In: MEHRA, P.N. Chromosome numbers in Himalayan ferns. Res. Bull. Panjab Univ. Sci. 12:13-164.

NEW FINDINGS OF PTERIDOPHYTES FROM THE MOUNTAIN RAINFORESTS OF SÃO TOMÉ AND PRÍNCIPE.

E. FIGUEIREDO

Centro de Botânica, Instituto de Investigação Científica Tropical, Trav. Conde da Ribeira 9, 1300 Lisboa, Portugal.
(Email: e.p.figueiredo@mail.telepac.pt)

Key words: Gulf of Guinea, Príncipe, pteridophytes, São Tomé.

ABSTRACT

New distribution data and habitat details on ten species of pteridophytes unrecorded in the islands of São Tomé and Príncipe for the last 40 to 100 years are presented.

FINDINGS

During a botanical expedition to the islands of São Tomé and Príncipe (Gulf of Guinea) in July 1999 (Figueiredo, Arriegas & Chozas) several pteridophytes were collected. Some had not been recorded in these islands for the last 40 to 100 years. These new findings expand the distribution areas of some taxa, treated in previous work (Figueiredo, 1998), and provide better information for the evaluation of their conservation status.

1. Asplenium lividum Mett. ex Kuhn, Linnaea 36: 100. 1869.

SÃO TOMÉ: Mendes Leite, Valley of Rio Contador, 600m alt., 25 July 1999, *Figueiredo, Arriegas, Chozas & Gascoigne 170* (LISC).
On the humid and shaded slopes at the edge of a path, in secondary forest. Not recorded since 1932.

2. Asplenium unilaterale Lam., Encycl. 2: 305. 1786.

SÃO TOMÉ: Milagrosa to Zampalma, 690m alt., 27 July 1999, *Figueiredo, Arriegas & Chozas* 184 (LISC); Macambrará to Zampalma, 850m alt., 30 Sept. 1997, *Lejoly 97/334* (LISC).

On a humid and shaded road edge (*Figueiredo, Arriegas & Chozas 184*), and in dense rainforest (*Lejoly 97/334).* Not recorded since the 19th century.

3. Bolbitis acrostichoides (Afzel. ex Sw.) Ching in C. Chr., Index filic. Suppl. 3: 47. 1934.

SÃO TOMÉ: Milagrosa to Zampalma, 690m alt., 27 July 1999, *Figueiredo, Arriegas & Chozas 183* (LISC).

Collected on a humid and shaded road edge. Not recorded since the 19th century.

4. Coniogramme africana Hieron., Hedwigia 57: 293. 1916.

SÃO TOMÉ: Bom Sucesso to Lagoa Amélia, 1153-1483m alt., 15 July 1999, *Figueiredo, Arriegas, Chozas & Oliveira 145* (LISC); Macambrará to Zampalma, 920m alt., 30 Sept. 1997, *Lejoly 97/331* (LISC); Lagoa Amélia, 1430m alt., 4 Oct. 1997, *Lejoly 97/365* (LISC); Calvário, 1550m alt., March 1998, *Oliveira 451* (LISC); Lagoa Amélia, 1300-1400m alt., 28 June 1991, *Paiva 57 & 63* (COI).

Occurs in primary and secondary rainforests and on the edges of forest paths and roads. It has also been collected on the edge of a crater (*Lejoly 97/365*). Although it was not recorded since the 1950's, this species is not rare and has been collected several times recently.

5. Lomariopsis hederacea Alston, J. Bot. 72, Suppl. 2: 5. 1934.

SÃO TOMÉ: Bom Sucesso to Lagoa Amélia, 1150-1480m alt., 15 July 1999, *Figueiredo, Arriegas, Chozas & Oliveira 143* (LISC); Vale Carmo to Pico Maria Fernandes, 290m alt., 10 Nov. 1995, *Carvalho 1* (LISC). PRÍNCIPE: E slopes of Pico, 500-800m alt., 4 April 1999, *Gascoigne 25* (LISC).

Occurs in primary and secondary forests and it has also been collected near forest paths. It was not recorded since 1932 and it is a new record for the island of Príncipe. All cited specimens are sterile. According to A. Gascoigne (pers. comm.) this species is common in the islands. The lack of collections may be due to the fact that sterile specimens are usually not collected. Possibly fertile specimens are restricted to tree canopies where they are epiphytes, and not within reach of collectors.

6. Pellaea doniana Hook., Sp. fil. 2: 137, t. 125 fig.A. 1858.

SÃO TOMÉ: Mendes Leite, Valley of Rio Contador, 595m alt., 25 July 1999, *Figueiredo, Arriegas, Chozas & Gascoigne 166* (LISC).

On a humid, shaded and rocky slope at the edge of a path, in secondary forest. Although it was recently (1973) collected in a small islet in the south of the island, it has not been collected in the island itself since the 19th century.

7. Pteris pteridioides (Hook.) F. Ballard, Kew Bull. 1937: 348. 1937.

SÃO TOMÉ: Bom Sucesso to Lagoa Amélia, 1150-1480m alt., 15 July 1999, *Figueiredo, Arriegas, Chozas & Oliveira 139* (LISC).

On the shaded and humid edge of a path in the rainforest. Not recorded since 1913. It is possible that collectors have overlooked this fern due to its superficial similarity to *Pteris paucipinnata*, a species more common in the island, also found in this locality.

8. Selaginella molleri Hieron. in Engl. & Prantl, Nat. Pflanzenfam. 1(4): 697. 1901.

SÃO TOMÉ: Milagrosa to Zampalma, 690m alt., 27 July 1999, *Figueiredo, Arriegas & Chozas 185* (LISC); Milagrosa to Bombaim, 490m alt., 28 July 1999, *Figueiredo, Arriegas & Chozas 194A* (LISC).

On the rocky, wet walls bordering a waterfall (*Figueiredo, Arriegas & Chozas 194A*) and in humid, rocky slopes on the edge of roads (*Figueiredo, Arriegas & Chozas 185*). Not recorded since 1932.

9. Trichomanes erosum Willd., Sp. pl. 5: 501. 1810.

SÃO TOMÉ: Vale Carmo, 180m alt, 17 July 1999, *Figueiredo, Arriegas, Chozas & Gascoigne 158* (LISC).
Collected in a very shaded and humid area of the rainforest, on a rock. Not recorded since the 1950's.

10. Trichomanes radicans Sw., J. Bot. (Schrader) 1800 (2): 97. 1801.

SÃO TOMÉ: Bom Sucesso to Lagoa Amélia, 1153-1483m alt., 15 July 1999, *Figueiredo, Arriegas, Chozas & Oliveira 138* (LISC); Bom Sucesso to Lagoa Amélia, 1250m alt., 25 Sept. 1997, *Lejoly 97/228* (LISC); Bom Sucesso to Morro Claudina, 1250m alt., 2 Oct. 1997, *Lejoly 97/353* (LISC); Estação Souza, 1460m alt., March 1997, *Oliveira 465* (LISC); Esperança, 29 June 1991, *Paiva 95* (COI).
Occurs in primary rainforest and it has also been found near the edges of paths in secondary forests. Not recorded since 1932.

ACKNOWLEDGEMENTS

Thanks are due to FCT-Portugal (PRAXIS XXI programme) for sponsoring the expedition to São Tomé and Príncipe during which these ferns were collected and to Angus Gascoigne for helping with field work. I also thank the referee for the comments on the manuscript.

REFERENCES

FIGUEIREDO, E. 1998. The pteridophytes of São Tomé and Príncipe (Gulf of Guinea). Bull. Nat. Hist. Mus. Lond. (Bot.) 28 (1): 41-66.

BOOK REVIEW

BRACKEN FERN: TOXICITY, BIOLOGY AND CONTROL. J.A.Taylor and R.T.Smith (Eds). 2000. 218pp. International Bracken Group, Leeds. Price £40.00 (including postage and packing). ISBN 0 9525505. Softback.

This volume is the fourth to be published by the International Bracken Group and includes contributions to Bracken'99, the fourth International Bracken Conference, held in Manchester in July 1999. It consists of 40 papers arranged in five sections reflecting the broad research and interest that this problem weed engenders. The first section consists of two introductory scene setting chapters, which commence with a brief but useful overview of the spread of bracken, the associated and perhaps heightened risks and what can realistically be achieved, followed by a look at GIS (Geographical Information Systems) visualisation techniques and their potential for analytical use on Bracken spread, control, etc. The second section is allegedly devoted to taxonomy, although the paper by Alonso-Amelot and co-workers is a phytochemical and autecological study of two Bracken taxa in northern South America and is clearly misplaced here. The remaining papers are a rather mixed bag ranging from brief regional observational studies desperately in need of editing and proofing (a common failing), to a weighty global synthesis of the genus using both molecular and morphometric analyses. J.A. Thomson's global perspective is long overdue and very welcome! It still leaves many questions unanswered and gives sufficient leeway for splitting and lumping factions still to claim support for their positions. This section concludes with a multi-gene molecular study of British and North American material by W. Speer which clarifies the relationships of *latiusculum* type plants in Britain and finds no support for the recognition of *P. pinetorum* at specific rank and brief papers by N.I.Shorina & O.N.Perestoronina and E.Ershova on the Bracken(s) of European Russia and the Caucasus, and Siberia, respectively. The first of these reduces *pinetorum* to varietal rank under *P.aquilinum* but this solution fails to show that the relationship is with *latiusculum* not *aquilinum sensu stricto*. We are also introduced to *P. tauricum* (C.Presl) V.Krecz. a taxon previously treated in Flora Europaea at subspecific rank under *P. aquilinum* as subsp. *brevipes* (Tausch) Wulf. The relationship of this to earlier described taxa from the Caucasus and recognition at specific rank will I'm sure form the basis of further work. As one who has published on Bracken taxonomy I know the strength of feeling and polarity which exists over the recognition and rank, at least of some of the more recently described British taxa. The editors, perhaps wisely, refrain from explicitly coming down on a particular side in this compilation but the inclusion of a foreword by C.M. (sic). Page, who wasn't at the meeting and the exclusion of an abstract for a paper that was presented by Ashcroft et al. has been seen by some as tacit support for the splitting camp! At least the various merits of the arguments are here presented for the impartial observer to decide.

Section three focuses on Bracken phytochemistry with three papers looking at the occurrence of various carcinogenic glucosides and related compounds, their wider distribution in related ferns and the factors which might effect their abundance …

Continued on p. 200

NEW PTERIDOPHYTE RECORDS FROM SICHUAN, CHINA AND THEIR GEOGRAPHICAL SIGNIFICANCE

H.-S. KUNG[1] & L.-B. ZHANG[1,2]

[1]Chengdu Institute of Biology, the Chinese Academy of Sciences, Chengdu 610041, PR China. [2]Author for correspondence. Present address: Institut für Spezielle Botanik, Johannes Gutenberg Universität, D-55099 Mainz, Germany. ([2]Email: ZHANL007@mail.uni-mainz.de)

Key words: *Huperzia dixitiana, Plagiogyria glauca, Leucostegia immersa, Woodsia manchuriensis, Cheiropleuria bicuspis*, new records, Sichuan, China

ABSTRACT

Five pteridophytes, *Huperzia dixitiana*, *Plagiogyria glauca*, *Leucostegia immersa*, *Woodsia manchuriensis* and *Cheiropleuria bicuspis*, are reported here as new records for Sichuan, China.

INTRODUCTION

Sichuan, located in southwest China and with 560,000 km^2 territory, is very rich in not only seed plants but also pteridophytes. There are *c.* 736 species of ferns and fern-allies in Sichuan (Kung, 1984). The pteridophyte flora of Sichuan is characterised by the abundance of *Polystichum* Roth (Dryopteridaceae), *Dryopteris* Adans (Dryopteridaceae) and *Athyrium* Roth (Athyriaceae) etc., and it is an important part of the *Polystico-Dryopteris* flora (Kung, 1984). With the publication of *Flora Sichuanica* volume 6 (Kung, 1988) and many other recent studies (Kung, 1984; Kung *et al.*, 1995a, 1995b; Zhang, 1994; Zhang *et al.*, 1995a, 1995b; Kung & Zhang, 1996; Zhang & Kung, 1998a), the knowledge of the pteridophyte flora of Sichuan has been improved. However, new members of this flora are always being found. This is a report of five new recorded pteridophytes with interesting geographical distributions from Sichuan:

1. Huperzia dixitiana P.Mondal & R.K.Ghosh, Fern Gaz. 15 (2): 72. f. 1 & 2. 1995.

Specimen cited: CHINA. Sichuan: Kangding, on rocks, alt. 3620 m, 17 Sept. 1934, *Zheng-Shu Liu 1542* (PE).

Distribution: China: Tibet (Mondal & Ghosh, 1995), Sichuan; Sikkim, Nepal and Burma (Mondal & Ghosh, 1995).

In our study of Huperzia Bernh. sect. *Serratae* (Rothm.) Holub (Zhang & Kung, 2000), we noticed the specimen cited here.

This is a small *Huperzia* and looks like *H. selago* (L.) Bernh. ex Schrank & Mart (Zhang & Kung, 1998b), but it has teeth in the apical region of the leaves. However, our specimen differs from the type (photo) of *H. dixitiana* in that the leaves are mostly flat instead of incurved. Perhaps it is an old individual.

Kangding, with the coordinates of 30°03'00"N and 102°02'00E, forms the western and northern distribution boundary of *H. dixitiana*.

2. Plagiogyria glauca (Blume) Mett., Farngatt. 2: 273. 1858.

P. glaucescens Ching, Acta Phytotax. Sin. 7(2): 124, 150, pl. 38, f. 2. 1958. *P. glaucescens* Ching var. *arguta* Ching, l. c. 125.

Specimen cited: CHINA. Sichuan: Shimian, alt. 2000 m, *Li-Bing Zhang 1995* (CDBI, PYU).

Distribution: China: Sichuan, NW Yunnan (Chu & Lu, 1993), SE Tibet (Ching, 1958, 1959; Ching & Wu, 1983), Taiwan (Zhang & Nooteboom, 1998); N India, N Burma (Ching, 1958, 1959; Ching & Wu, 1983), Philippines, Indonesia and the Pacific countries (Zhang & Nooteboom, 1998).

When R.C. Ching described *P. glaucescens* Ching, he published a variety *P. glaucescens* var. *arguta* Ching (1958). According to the original description, this variety is characterised only by its longer and sharper teeth on the leaves. It occurs in northwest Yunnan. We do not accept this variety.
Our specimen (*Li-Bing Zhang 1995*) was collected from Shimian, west Sichuan. This is another species from the center of diversity of the genus - southwest China. According to the study by R. C. Ching (Ching, 1958), the genus occurs mainly in high mountains. The vertical distribution of *P. glaucescens* was recorded as 2600-3200 m, but our specimen was collected at the altitude of 2000 m, which is far lower than the earlier records.

3. Leucostegia immersa (Wall.) C.Presl. Tent. pterid. 95. pl. 4. f. 11. 1836.
Davallia immersa Wall. ex Hook. Sp. fil. 1: 156. 1846.

Specimen cited: CHINA. Sichuan: Yanbian, Mt. Bailing, alt. 3500 m, 14 July 1978, *Xichang Inst. Pharm. 0220* (SM; photocopy, CDBI).

Distribution: China: Guangxi (ASBI, 1972), Taiwan (Devol, 1975), Sichuan, Yunnan (Cheng, 1993; Chu & Lu, 1993), Tibet (Ching & Wu, 1983); India, Sikkim, Bhutan, Nepal (Dixit, 1984), Burma (Nooteboom, 1992, 1996), southeast Asia, Polynesia (Tardieu-Blot & Christensen, 1939; Holttum, 1966), New Guinea and Papua New Guinea (Nooteboom, 1992).

Leucostegia C.Presl is an Asian genus and a tropical component. It comprises only two species (Nooteboom, 1992), which occur contiguously and sympatrically. *Leucostegia immersa* is the northern one and has a wider distribution area (Nooteboom, 1992, 1996).

4. Woodsia manchuriensis Hook., Sec. cent. ferns. tab. 98. 1861.

Specimen cited: CHINA. Sichuan: Hongya, Mt. Washan, alt. 1950-2500 m, 8 June 1994, *Wei-kai Bao et al. 2001, 2589, 2649* (CDBI).

Distribution: China: northeast China (Zhang *et al.*, 1958; Li & Wang, 1988; Wu & Bai, 1998), north China, northwest (Hsu & Ching, 1974), east China (Ching, 1945), Sichuan; Japan (Ogata, 1933; Tagawa, 1959; Nakaike, 1982), Korea (Tagawa, 1959), E Russsia (Fomin, 1934).

Using the name of *Protowoodsia manchuriensis* (Hook.) Ching (Ching, 1945), Xia (1993) reported the distribution of this species in Sichuan, but all the specimens which he cited are *Woodsia kangdingensis* H.S. Kung, L.B. Zhang & X.S. Guo according to our study (Kung *et al.*, 1995b). Furthermore, we doubt the occurance of *W. manchuriensis* in Yunnan.

5. Cheiropleuria bicuspis (Blume) C.Presl, Epimel. bot. 189. 1851.
Polypodium bicuspe Blume, Enum. pl. Javae. 1828.

Specimen cited: CHINA. Sichuan: Hejiang, Fubao, alt. 900 m, 6 Aug. 1977, *Junliang Inst. Pharm. He-87* (SM; photocopy, CDBI).

Distribution: CHINA: Zhejiang (Zhang, 1993), Guangdong, Guangxi, Hainan (Hu & Ching, 1930; Ching *et al.*, 1964), Taiwan (Devol, 1975), Sichuan; Japan (Tagawa, 1959; Nakaike, 1982), Indochina Peninsula, Philippines, Malaysia, Indonesia, New Guinea (Holttum, 1966).

The first author of this paper noted four families which were new to Sichuan in 1984 (Kung, 1984): Monachosoraceae, Elaphoglossaceae, Dipteridaceae, Cheiropleuriaceae, but he did not point out the related species names and failed to cite the specimens. In the last ten years, the first three families were reported from Sichuan by others (Kung, 1989; Chu & Lu, 1993); here is the official report of the last family, Cheiropleuriaceae.

The specimen cited here was collected from Hejiang by the Yangtze River, at a latitude of 29° N. This is the northern boundary of this family on the mainland of Asia. Cheiropleuriaceae is a monotypic Asian tropical family (Kramer, 1990), its distribution pattern is something like those of *Elaphoglossum* J. Smith and *Dipteris* Reinwardt (Kramer, 1990). It is interesting that there are some tropical components in the fern flora of Sichuan, but most of them have their northern distribution boundary in Sichuan.

ACKNOWLEDGEMENTS

We thank Prof. Wei-Ming Chu (Kunming) and Dr Hans P. Nooteboom (Leiden) for valuable comments on the manuscript. The study was supported by the Chengdu Diao Science Fund

REFERENCES

ASBI, Botanical Institute of Academia Sinica. 1972. Iconographia Cormophytorum Sinicorum 1. Science Press, Beijing.

CHENG, X. 1993. Plagiogyriaceae, Davalliaceae. In: WANG, W.T. (Ed.), Vascular plants of the Hengduan Mountains 1, pp. 17-18. Science Press, Beijing.

CHING, R.C. 1945. The studies of Chinese ferns XXXII, Lingnan Sci. Journ. 21: 31-37. 1945.

CHING, R.C. 1958. The fern genus *Plagiogyria* on the mainland of Asia. Acta Phytotax. Sin. 7(2): 105-154.

CHING, R.C. 1959. Flora reipublicae popularis sinicae 2. Science Press, Beijing.

CHING, R.C., WANG, Z.H. & WU, S.H. 1964. Pteridophyta. In: CHUN, W.Y. (Ed.) Flora Hainanica 1, pp. 1-206. Science Press, Beijing.

CHING, R.C. & WU, S.K. 1983. Pteridophyta. In: WU, C.Y. (Ed.) Flora Xizangica 1, pp. 1-355. Science Press, Beijing.

CHU, W.M. & LU, S.G. 1993. Pteridophyta. In: LI, H. (Ed.) Flora of Dulongjiang region, pp. 1-43. Yunnan Science & Technology Press, Kunming.

DEVOL, C.E. 1975. Cheiropleuriaceae. In: LI, H.L. (Ed.) Flora of Taiwan 1, pp. 163-164. Epoch Publishing Co. Ltd., Taipei.

DIXIT, R.D. 1984. A census of the Indian pteridophytes. Botanical Survey of India, New Dehli.

FOMIN, A.V. 1934. Woodsiaceae. In: KOMOROV, V.L. (Ed.) Flora URSS 1, pp. 19-30. Academy of Nauk, SSSR, Leningrad.

HOLTTUM, R.E. 1966. A revised flora of Malaya 2, Ferns of Malaya. Government Printing Office, Singapore.

HSU, Y.P. & CHING, R.C. 1974. Flora Tsinlingensis 2. Science Press, Beijing.

HU, H.H. & CHING, R.C. 1930. Icones filicum sinicum I. The Metropolitan Museum of National History, Academia Sinica, Nanking (Nanjing), China and The Fan Memorial Institute of Biology, Peiping (Beijing), China.

KRAMER, K.U. 1990. Cheiropleuriaceae, Dipteridaceae, Lomariopsidaceae. In: KRAMER, K.U. & GREEN, P.S. (Eds) The families and genera of vascular plants I, Pteridophytes and gymnosperms, pp 68-69; 99-101; 164-170. Springer-Verlag, Berlin.

KUNG, H.S. 1984. The phytogeographical features of pteridophytes of Sichuan, China, with some remarks on the "*Polysticho-Dryopteris* flora". Acta Bot. Yunnan. 6 (1): 27-38.

KUNG, H.S. 1988. Flora Sichuanica 6. Sichuan Science & Technology Press, Chengdu.

KUNG, H.S. 1989. *Dipteris chinensis*. In: KAO, P.C. (Ed.) The rare and endangered plants of Sichuan, pp. 186. Sichuan Nationality Press, Chengdu.

KUNG, H.S., ZHANG, L.B. & GUO, X.S. 1995a. New materials of *Dryopteris* from Mt. Gongga (Minya Gonkar), Sichuan, China. Acta Bot. Yunnan 17(2): 159-161.

KUNG, H.S., ZHANG, L.B. & GUO, X.S. 1995b. New materials of pteridophytes from Mt. Gongga (Minya Gonkar), Sichuan, China. Acta Bot. Yunnan. 17(4): 420-422.

KUNG, H.S. & ZHANG, L.B. 1996. The features of the pteridophytic flora of Mt. Gongga (Minya Gonkar), Sichuan, China. Acta Bot. Yunnan. 18(2): 176-184.

LI, S.X. & WANG, J.Z. 1988. Pteridophyta. In: LI, S.X. (Ed.), Flora Liaoningica 1, pp. 10-125. Liaoning Science and Technology Publishing House, Shenyang.

MONDAL, P. & GHOSH, R.K. 1995. A new species of *Huperzia* (Lycopodiaceae: Pteridophyta) from India. Fern Gaz. 15 (2): 71-74.

NAKAIKE, T. 1982. New flora of Japan (pteridophytes). Shibundo Co. Ltd. Publishers Tokyo, Tokyo.

NOOTEBOOM, H.P. 1992: Notes on Davalliaceae I. The genera *Araiostegia*, *Davallodes*, *Leucostegia*, and *Gymnogrammitis*. Blumea 37: 165-187.

NOOTEBOOM, H.P. 1996: Davalliaceae of China. Acta Phytotax. Sin. 34 (2): 162-179.

OGATA, M. 1933. Icones filicum japoniae 5. Sansyusya, Tokyo.

TAGAWA, M. 1959. Coloured illustrations of the Japanese pteridophyta. Hoikusha Publishing Co., Ltd., Osaka.

TARDIEU-BLOT, M.L. & CHRISTENSEN, C. 1939. Polypodiaceae (Davallioides). In: LECOMT, H. (Ed.), Flore generale de l'Indo-Chine 7 (2), pp. 103-118. Paris.

WU, C.J. & BAI, X.L. 1998. Pteridophyta. In: MA, Y.Q. (Ed.), Flora intramongolica, 2nd Edition 1, pp. 178-248. Typis Intramongolicae Popularis, Huhohot.

XIA, Q. 1993. Woodsiaceae. In: WANG, W.T. (Ed.), Vascular plants of the Hengduan mountains 1, pp. 112-113. Science Press, Beijing.

ZHANG, C.F. 1993. Pteridophyta. In: ZHANG, C.F. & ZHANG, S.Y., Flora of Zhejiang 1, pp. 1-337. Zhejiang Science & Technology Press, Hangzhou.
ZHANG, L.B. 1994. A taxonomic study on the fern genus *Polystichum* sect. *Metapolystichum* from Sichuan, China. Acta Bot. Yunnan. 16(2): 131-138.
ZHANG, L.B., WANG, Z.R. & GUO, X.S. 1995a. New ferns of Athyriaceae from Mt. Gongga (Minya Gonkar), Sichuan, China. Acta Bot. Yunnan. 17(3): 302-304.
ZHANG, L.B., KUNG, H.S. & GUO, X.S. 1995b. New taxa of *Polystichum* Roth from Mt. Gongga (Minya Gonkar), Sichuan, China. Acta Bot. Yunnan. 17(1): 25-29.
ZHANG, L.B. & KUNG, H.S. 1998a. New materials of the fern genus *Polystichum* Roth from West China. Acta Phytotax. Sin. 36(3): 242-254.
ZHANG, L.B. & KUNG, H.S. 1998b. A taxonomic study of *Huperzia* Berhn. (s. str.) sect. *Huperzia* in China. Acta Phytotax. Sin. 36(6): 521-529.
ZHANG, L.B. & KUNG, H.S. 2000. Taxonomy of *Huperzia* Bernh. (s. str.) sect. *Serratae* (Rothm.) Holub in China. Acta Phytotax. Sin. 38 (1): 13-22.
ZHANG, X.C. & NOOTEBOOM, H.P. 1998. A taxonomic revision of Plagiogyriaceae (Pteridophyta). Blumea 43: 401-469.
ZHANG, Y.L., LI, S.X., FANG, Z.F. & LU, D.Q. 1958. Ophioglossaceae – Aspidiaceae. In: LIOU, T.N. (Ed.) Flora of herbaceous plants of northeast China 1. pp. 18-63. Science Press, Beijing.

BOOK REVIEW

BRACKEN FERN: TOXICITY, BIOLOGY AND CONTROL. J.A.Taylor and R.T.Smith (Eds). Continued from p.194.

... in cows milk. This leads seamlessly into the fourth section "Bracken and Human and Animal health" which with 14 chapters comprises the main portion of the volume.

Overviews of *Pteridium* toxicity in animal and human health (Smith *et al.*) and the mechanism of carcinogenesis (Shahin *et al.*) sit alongside more specific studies on factors affecting particular tumours of cattle and carcinoma development – little here for the fern enthusiast. Perhaps the most pertinent paper to readers of this journal was that of Simán *et al.* (published also in the British Journal of Cancer) looking at the genotoxicity of not just Bracken but other fern spores. Of those tested all but *Osmunda* caused appreciable damage to DNA, which should give anyone working regularly in close proximity to dense sporing fern stands pause for thought!

Ecology, control and management includes a very useful account by Robinson laying out a comprehensive three stage strategy to provide effective Bracken clearance. He argues that previous failures have largely stemmed from the reliance on spraying alone without care for follow-up work with the resource implications that brings. This is followed by his paper in conjunction with Chris Page looking at the risks to, and protection of, other (non-target) pteridophyte species during herbicide spraying. An important issue now being addressed by work funded by English Nature.

This is followed by abstracts of other talks presented at the conference which had previously been published in a special volume of the Annals of Botany (Vol. 85, supplement B, 2000). This was the first time that the conference proceedings had been published in this parallel fashion, with authors understandably wishing their work to reach a larger audience in higher impact journals but it does seem to have caused difficulties and the resulting conference volume has undoubtedly suffered and readers must now consult both volumes for a complete account. The volume concludes with a series of short articles reflecting on the post conference field trip and summarising the conference – these are a welcome addition which I hope I.B.G. 5 will take on board.

In conclusion something of a curates egg, probably only for Bracken-aholics, although there are many papers of wider significance to countryside managers, toxicologists, etc. here. Well worth reading, but buying.....?

Fred J. Rumsey

TWO NEW SPECIES AND A NEW COMBINATION IN INDIAN AND SRI LANKAN GRAMMITIDACEAE

B. S. PARRIS

Fern Research Foundation, 21 James Kemp Place, Kerikeri, Bay of Islands, New Zealand
(Email: bsparris@voyager.co.nz)

Key words: India, Sri Lanka, Grammitidaceae, *Ctenopteris perplexa*, *Grammitis austroindica*, *Micropolypodium sikkimense*.

ABSTRACT

Ctenopteris perplexa and *Grammitis austroindica* are described as new species. The former is known from Sri Lanka and South India; the latter occurs only in South India. The new combination *Micropolypodium sikkimense* is also made.

INTRODUCTION

During the preparation of an account of the Grammitidaceae for the Flora of Ceylon, material of the family was also examined from India. Two new taxa resulting from this study are described here, one in *Ctenopteris* and one in *Grammitis*, and one new combination is made in *Micropolypodium*.

Ctenopteris perplexa Parris, ***sp. nov.***

A *C repandula* differt soris non in depressionibus et non ad superficiem laminae prominulis, lobis ad apicem emarginatis, truncatis, obtusis vel acutis.

Holotypus: Sri Lanka, Central Province, Nuwara Eliya District, Kandapola Forest Reserve, 1520 m alt., 19 March 1954, Sledge 1330 p.p. (K).

Rhizomes ± erect, radial, stipes in whorls of 3, not articulated to rhizome, scales 0.6-2.0 × 0.2-0.7 mm, lanceolate to ovate, acute to apiculate at apex, pale to medium red-brown, glabrous apart from 1-3 pale yellow-brown or pale red-brown simple eglandular or 1-2-forked hairs 0.1-0.6 mm at apex of scale, neither clathrate nor iridescent. Stipes winged to base or 1-4 × 0.3-0.8 mm; with whitish to pale yellow-brown simple eglandular hairs 0.2-0.8 mm and 1-3-forked hairs 0.2-0.6 mm. Laminae 33-170+ × 6-28 mm, narrowly elliptic to narrowly oblanceolate in outline, obtuse to acuminate at apex, long-attenuate at base, deeply pinnately divided, longest pinnae 3-15 × 1-4 mm, very narrowly triangular to narrowly oblong, obtuse to acuminate at apex, sessile to decurrent on acroscopic margin, decurrent on basiscopic margin at base, entire or lobed, longest lobes 0.8-2.7 × 0.2-1.1 mm, broadly oblong or broadly to narrowly triangular, emarginate, truncate, obtuse, bluntly acute or acute at apex, entire or slightly crenulate; with pale yellow-brown or pale to dark red-brown simple eglandular hairs 0.1-1.2 mm on both surfaces of rachis, abaxial surface of pinna mid-vein and margin, sometimes on both surfaces of lamina, including as receptacular paraphyses, and adaxial surface of pinna mid-vein, and pale yellow-brown or pale to medium red-brown 1-3-forked hairs 0.1-0.9 mm on abaxial surface of rachis, sometimes on both surfaces of lamina and pinna mid-

vein, margin and adaxial surface of rachis; rachis prominent and concolorous or slightly darker than lamina on both surfaces, lateral veins simple, each ending marked by a hydathode 0.1-0.3 × 0.1-0.2 mm. Sori 0.7-1.9 × 0.6-1.7 mm, on surface of lamina, discrete to confluent when mature, in 2 rows per pinna, 1 each side of pinna mid-vein, 1-7 per row on longest pinnae. Sporangia 170-280 μm, glabrous; indurated cells of annulus 7-14. Spores 33-60 μm diam.

Known from Sri Lanka and South India. Epiphyte on mossy tree trunks, sometimes growing with bryophytes; from c. 1220-1860 m alt.

Grammitis austroindica Parris, ***sp. nov.***

In aspectu *G. mediali* soris extra-medialibus, sed differt rhizomate longiore repenti cum stipitibus dissitioribus, pilis stipitum longioribus minus densisque, sporangiis glabris.

Holotypus: South India, Nilgiris, herb. *Beddome* s. n. (BM).

Rhizomes long-creeping, dorsiventral, stipes in 2 rows, not articulated to rhizome, 1.3-2.7 mm apart in each row, scales 1.0-2.1 × 0.4-0.7 mm, lanceolate, acute at apex, medium red-brown, glabrous, not clathrate, sometimes slightly iridescent. Stipes 1-6 × 0.3-0.6 mm, with medium to dark red-brown simple eglandular hairs 0.8-1.3 mm. Laminae 37-75 × 3-9 mm, narrowly elliptic, acute at apex, long-attenuate at base, entire; with dark red-brown simple eglandular hairs 0.3-1.0 mm on adaxial surface of lamina and mid-vein, and margin, sometimes on abaxial surface of lamina and mid-vein, and translucent to pale red-brown catenate simple glandular hairs 0.1-0.2 mm on abaxial surface of lamina and mid-vein; fertile veins simple or 1-(2-)forked, free, each branch ending marked by a hydathode 0.1-0.2 × 0.1 mm. Sori 1.7-2.2 × 1.5-1.9 mm, on surface of lamina, discrete to contiguous when mature, in 2 rows, 1 each side of mid-vein, 3-17 in each row, nearer to margin than mid-vein. Sporangia 220-270 μm, glabrous; indurated cells of annulus 10-13. Spores 36-39 μm diam.

Known only from the South India (Nilgiris) type collection. Growing with bryophytes and lichens; altitude unknown.

Micropolypodium sikkimense (Hieron.) Parris, ***comb. nov.***.

Polypodium sikkimense Hieron., Hedwigia 44: 97 (1905). *Ctenopteris sikkimensis* (Hieron.) C.Chr. & Tardieu, Notul. Syst. (Paris) 8(4): 182 (1939). *Grammitis sikkimensis* (Hieron.) Ching, Bull. Fan Mem. Inst. Biol. 10: 15 (1940). *Xiphopteris sikkimensis* (Hieron.) Copel., Gen. fil., 215 (1947).

ACKNOWLEDGEMENTS

I am most grateful to the curators of BM and K for the loan of specimens, and to the curator of AK for organising the loans.

INSTRUCTIONS FOR AUTHORS

Manuscripts on all subjects of pteridology are welcome and should be sent to the editor: Miss J.M. Camus, Department of Botany, The Natural History Museum, Cromwell Road, London SW7 5BD, UK; fax +44-(0)20-7942 5529; email j.camus@nhm.ac.uk.

PLEASE NOTE that papers should not usually exceed 20 printed pages and are generally expected to be considerably shorter. Longer review articles will be considered. Short notes are acceptable e.g. new records. The senior author should supply fax and email numbers to facilitate correspondence.

MANUSCRIPTS should be written in English (British), double spaced, preferably on A4 paper. Three hard copies are required in the first instance; a version on disc will be required after revision (WORD 97 in WINDOWS 95, DOS). All manuscripts will be refereed. The title should reflect the content of the paper and be in **BOLD CAPITALS** and centrally aligned. Generic and specific names should be in italics and any title containing a generic or specific name must be followed by the family and Pteridophyta in brackets e.g.

TRICHOMANES SPECIOSUM WILLD. (HYMENOPHYLLACEAE: PTERIDOPHYTA) IN SOUTHERN SPAIN

AUTHOR ABBREVIATIONS should follow Pichi Sermolli's (1996) Authors of scientific names in Pteridophyta, Royal Botanic Gardens, Kew.

MAIN HEADINGS: in BOLD CAPITALS and centrally aligned.

SUBSIDIARY HEADINGS: in italics and left aligned.

AUTHORS' NAMES AND FULL ADDRESSES: following the title and centrally aligned.

KEY WORDS: up to ten.

ABSTRACT: should reflect the content of the paper.

FIGURES: there is no distinction between photographs and line drawings in numbering, but maps should be numbered separately. All should be presented in a form ready for reproduction, ideally as TIF format (please contact editor with queries), with a scale bar where appropriate. Lettering or numbers (Arabic) should be in the bottom left using uppercase Times Roman and be sufficiently large to be legible if reduction is necessary during printing. The number of photographs allowed in any one issue is limited by cost. Figure captions should be on a separate sheet.

TABLES: can be printed in either portrait or landscape format. Authors should consider this when they are preparing tables. Authors should ensure that tables fit the printed page size in a legible form.

MEASUREMENTS: should follow the metric system.

CHECKLISTS: should follow the format of Baksh-Comeau, Fern Gaz. 16(1, 2): 11-122.

REFERENCES: should follow the style of the current issue of The Fern Gazette, e.g.:-

HOOKER, W.J. 1864. Species Filicum, 5. Dulau & Co., London.

MORTON, C.V. 1947. The American species of *Hymenophyllum*, section *Sphaeroconium*. Contr. U.S. Natl. Herb. 29(3): 139-201.

STEVENSON, D.W. & LOCONTE, H. 1996. Ordinal and familial relationships of pteridophyte genera. In: CAMUS, J.M., GIBBY, M. & JOHNS, R.J. (Eds) Pteridology in perspective, pp. 435-467. Royal Botanic Gardens, Kew.

JOURNAL ABBREVIATIONS: should follow Botanico Periodicum Huntianum & Supplements.

Alterations from the original text at proof stage will be charged for unless they are minor points of detail. Twenty five offprints will be supplied free to the senior author.

SYMPOSIUM ANNOUNCEMENT

Fern Flora Worldwide: Threats and
Responses

An International Symposium
23-26 July 2001
University of Surrey, Guildford, UK

British Pteridological Society
with
IUCN Species Survival Commission Specialist Group for Pteridophytes

http://www.eBPS.org

THE BRITISH PTERIDOLOGICAL SOCIETY

Patron: HRH The Prince of Wales

Officers and Committee from March 2001

President: **Prof. A.C. Wardlaw**, 92 Drymen Road, Bearsden, Glasgow G61 2SY
E-mail: President@eBPS.org.uk

Vice-Presidents: **A.R. Busby, Dr N.J. Hards, M.H. Rickard, Prof. B.A. Thomas, Dr T.G. Walker**

Honorary General Secretary: **Miss J.M. Ide**, 42 Crown Woods Way, Eltham, London SE9 2NN
Tel./Fax: 020 8850 3218; E-mail: Secretary@eBPS.org.uk

Treasurer: **A. Leonard,** 11 Victory Road, Portsmouth, Hants. PO1 3DR
E-mail: Treasurer@eBPS.org.uk

Membership Secretary: **M.S. Porter,** 5 West Avenue, Wigton, Cumbria CA7 9LG
Tel.: 016973 43086; E-mail: Membership@eBPS.org.uk

Meetings Secretary: **P.J. Acock**, 13 Star Lane, St Mary Cray, Kent BR5 3LJ
E-mail: Meetings@eBPS.org.uk

Conservation Officer/Recorder: **R.J. Cooke**, 15 Conduit Road, Stamford, Lincs. PE9 1QQ
E-mail: Conservation@eBPS.org.uk

Editor of the Bulletin: **Miss A.M. Paul,** Department of Botany, The Natural History Museum, Cromwell Road, London SW7 5BD; E-mail: Bulletin@eBPS.org.uk

Editors of the Fern Gazette: **Miss J.M. Camus** & **J.A. Crabbe,** Department of Botany, The Natural History Museum, Cromwell Road, London SW7 5BD
E-mail: FernGazette@eBPS.org.uk

Editor of the Pteridologist: *Post vacant.* Please send articles to the President (address above)
E-mail: Pteridologist@eBPS.org.uk

*Editor of BPS WWW Site - **www.eBPS.org.uk**:* **A.C. Pigott,** Kersey's Farm, Mendlesham, Stowmarket, Suffolk IP14 5RB; E-mail: Webmaster@eBPS.org.uk

Committee: **R.G. Ackers, Dr A.F. Dyer, L. Kirkham, Ms E. Knox-Thomas, Dr S. Martinelli, Dr F.J. Rumsey, R.W. Sykes, B. Wright**

Booksales Organiser: **S.J. Munyard**, 234 Harold Road, Hastings, East Sussex TN35 5NG
E-mail: Booksales@eBPS.org.uk

Horticultural Information Officer: **A.R. Busby**, 16 Kirby Corner Road, Canley, Coventry CV4 8GD; E-mail: HorticulturalInformation@eBPS.org.uk

Merchandise Organiser: *Post vacant*

Plant Exchange Organisers: **Mr & Mrs R.J. Smith,** 184 Solihull Road, Shirley, Solihull, Warwicks. B90 3LG

Spore Exchange Organisers: **Mr & Mrs B. Wright,** 130 Prince Rupert Drive, Tockwith, York YO26 7PU; E-mail: Spores@eBPS.org.uk

Trustees of Greenfield & Centenary Funds: **Prof. A,C, Wardlaw, Miss J.M. Ide, A. Leonard**

The BRITISH PTERIDOLOGICAL SOCIETY was founded in 1891 and today continues as a focus for fern enthusiasts. It provides a wide range of information about ferns through the medium of its publications and other literature. It also organises formal talks, informal discussions, field meetings, garden visits, plant exchanges, a spore exchange scheme and fern book sales. The Society has a wide membership which includes gardeners, nurserymen and botanists, both amateur and professional. The Society's journals, the *Fern Gazette, Pteridologist* and *Bulletin,* are published annually. The *Fern Gazette* publishes matter chiefly of specialist interest on international pteridology, the *Pteridologist,* topics of more general appeal, and the *Bulletin,* Society business and meetings reports. **WWW site**: http://www.eBPS.org.uk

Membership is open to all interested in ferns and fern-allies. **SUBSCRIPTION RATES** (due on 1st January each year) are Full Personal Members £15, Personal Members not receiving the *Fern Gazette* £12, Student Members £9, Subscribing Institutions £25. Family membership in any category is an additional £2. Applications for membership should be sent to the Membership Secretary (address above) from whom further details can be obtained. (Remittances made in currencies other than Sterling are £5 extra to cover bank conversion charges.) **Airmail** postage for all journals is an extra £4, or for those not receiving the *Fern Gazette* £2.50. **Standing Order** forms are available from the Membership Secretary and the BPS web site.

Back numbers of the *Fern Gazette, Pteridologist* and *Bulletin* are available for purchase from P.J. Acock, 13 Star Lane, St Mary Cray, Kent BR5 3LJ; E-mail: BackNumbers@eBPS.org.uk.

SMITHSONIAN INSTITUTION LIBRARIES
3 9088 01486 1850

THE FERN GAZETTE

VOLUME 16 PART 4 2001

CONTENTS

ISSN 0308-0838